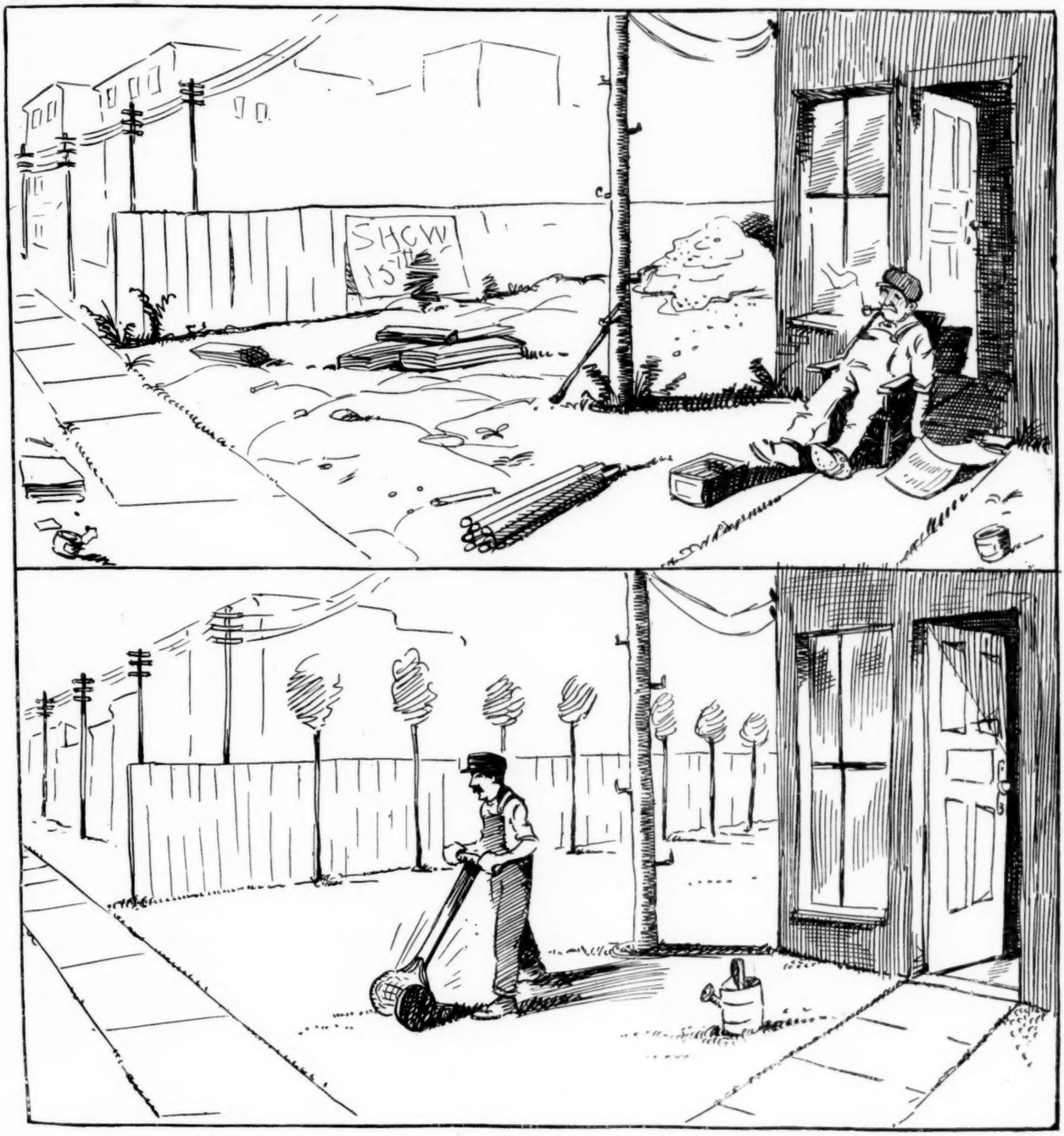
POWER

Vol. 43 NEW YORK, JUNE 6, 1916 No. 23



Two Ways of Using the Leisure Hours

Quitman Municipal Water and Light Plant

By F. B. Crowell*

SYNOPSIS—In 1914 the members of the City Council of Quitman, Ga., because of the uneconomical condition of the water and light plant and because of the high operating costs, decided to have the plant rebuilt. The new plant has been in operation since Jan. 1, 1916. Test figures are given.

The old municipally owned and operated plant at Quitman, Ga., was equipped with two tubular boilers and a Corliss engine, running noncondensing and belted to a 200-kw. 1,100-volt alternating-current generator. The electric service was furnished for about 14 hours per day.

The water-works equipment consisted of one steam-driven compound air compressor and two steam-driven compound service pumps, all operating noncondensing. The water is pumped from a 6-in. well 700 ft. deep, into a reservoir at the plant. From the reservoir it is pumped into the water tank in the city under a head of 60 lb. The water from the well is raised 115 ft. with an air lift, and from 300,000 to 350,000 gal. is pumped per day.

Condition of Old Plant

The old plant running under these conditions was using about 3,321 tons of coal per year at a cost of $11,291. The boilers were continually needing repairs, the engine was overloaded and the slipping and breaking of the belt necessitated frequent shutdowns for repairs.

The air compressor and steam pumps were in bad condition, and steam lines were uncovered and leaking in numerous places. The old plant was so arranged that the air compressor and pumps, and the Corliss engine, jackshaft and generator were all in one room in the front part of the building, the engine extending into an ell cut off from one end of the boiler room.

This ell in the remodeled plant (Fig. 1) was walled off from the engine room and made a part of the boiler room, and the new boilers were placed where the engine was formerly located. The other end of the boiler room was walled off, making a pumproom for the water-works apparatus. Into this room were moved the steam-driven air compressor and two steam-driven pumps. The new motor-driven air compressor and service pump were also placed there.

The two unaflow engines were placed in the newly arranged engine room, which is now about 50 feet square. These engines are right- and left-hand and are placed on each side of the main entrance. One of the units is shown in Fig. 2. Under the switchboard and between the engines a 30x30x11-ft. basement was excavated and walled up. This is covered over with a concrete floor except a well opening 12x15 ft., which is surrounded by a railing. In this basement are the surface condenser, vacuum and circulating pumps, also the cables from the generators, switches and 2,200-volt transformers.

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A cooling pond 40x60x4 ft. was constructed of concrete near the end of the pumproom. The spray cooling nozzles are over this pond, Fig. 3. The vacuum pump discharges the condensed water from the engine into a filter tank over the feed-water heater in the boiler room. The water flows through this filter, where all of the oil is removed, into a heater. The exhaust steam from the vacuum pump and the boiler-feed pump discharges into the heater, also the condensed water from the steam trap in the basement.

The steam lines from the boilers are connected into a 7-in. welded header, with all steel valves and fittings; the joints are lap-flanged. Over the main header is a 4-in. loop, all so connected that the engines and pumps can be operated from either boiler. All steam lines are covered with 85-per cent. magnesia pipe covering to reduce condensation losses.

All the new apparatus was purchased f.o.b. Quitman, Ga., and the work on the plant was done entirely by

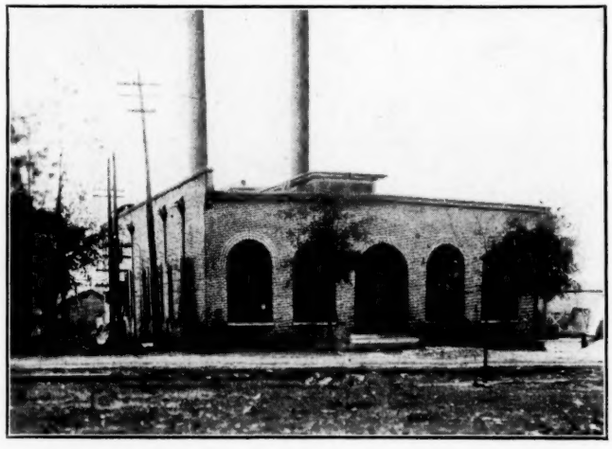


FIG. 1. EXTERIOR OF REMODELED PLANT

day labor, the city employing an engineer to superintend the work. All the equipment before being accepted by the city was tested by the engineers from the J. B. McCrary Co., Atlanta, Ga., and the tests show that they are fulfilling their guarantees. These consisted of five tests of 100 i.hp. at ¼ load, 200 at ½ load, 300 at ¾ load, 400 at full load and 500 i.hp. at 1¼ load. The steam pressure averaged 148 lb., and an average vacuum of 26.7 in. was carried. The average steam consumption for all loads was 11.92 lb. per i-hp.

During the first three months of 1916 the plant ran on a 24-hr. service with all the new equipment in use. The average load on the plant is light—about 70 kw. At present several motors are being installed about the city, and there will soon be a better average for the day load.

The operating results for these three months are given herewith, and they show the economy of the unaflow engine operating under a light load, or about 25 per cent. of its rated capacity.

THREE MONTHS' OPERATING RESULTS

1916	Kw.-Hr. Generated, Total	Average Kw. per Day	Total Lb. of Coal	Pounds per Kw.-Hr.	Price of Coal per Ton	Cost of Coal per Kw.-Hr.	Cost of Coal, Labor and Sundries per Kw.-Hr.
Jan.....	57,960	1,870	297,000	5.12	$3.30	$0.00845	$0.0140
Feb.....	47,240	1,629	213,800	4.53	3.30	0.00747	0.0136
Mar....	53,130	1,727	201,000	3.78	3.30	0.00623	0.0117

The rate of pounds of coal per kilowatt-hour is higher than it would be with full rated load. The unbalanced condition between the boilers and engine also accounts somewhat for the high figures. After the first two tests were run, 40 per cent. of the grate surface was blocked off and the amount of coal consumed per kilowatt-hour was reduced to 3.78 lb. as a result.

Pumping water from the 6-in. wells 700 ft. deep, 115-ft. lift, 93-lb. air pressure, 62-per cent. submergence, the 12&7½x12-in. motor-driven air compressor running at 167 r.p.m., 1,000 gal. cost $0.01988. The cost of pumping water from the reservoir into the water tower under 60 lb. pressure with the motor-driven centrifugal pump was $0.01316 per 1,000 gal. That of pumping from the well into the tower was $0.03304 per 1,000 gal.

Estimating an average load per day of 1,600 kw.-hr. for the year would make a total of 584,000 kw.-hr. generated. The cost of this with the old plant, with 3,321 tons of coal, was $11,291, or $0.01933 per kw.-hr. The cost for the same with the new plant will be, with 1,341 tons of coal, $4,336, or $0.00742 per kw.-hr. The saving on fuel per year under same load conditions will be $6,955.

The total cost of the improvements to the plant was $39,000, and the saving on coal, as stated in the foregoing, is estimated on the average load carried by the plant before these improvements were made. Other savings, especially in labor with an increased load, have also been obtained.

The J. B. McCrary Co., Atlanta, Ga., was retained by the city to make the plans and supervise the work, and under its supervision the apparatus listed in the table of principal equipment was purchased and installed.

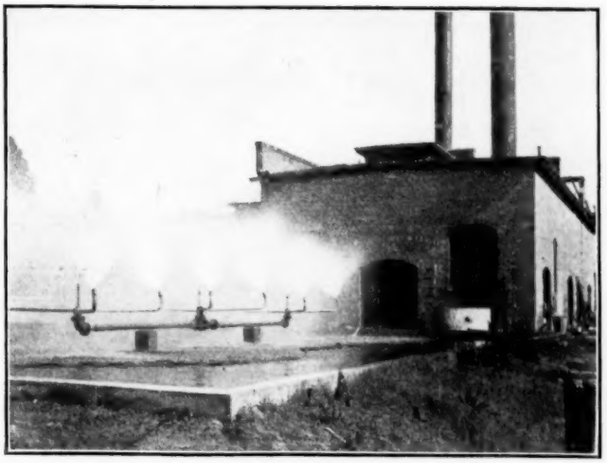


FIG. 3. THE SPRAY-COOLING POND

PRINCIPAL EQUIPMENT OF QUITMAN MUNICIPAL WATER AND LIGHT PLANT

No.	Equipment	Kind	Size	Use	Operating Conditions	Cost	Maker
2	Engines	Unaflow, side-crank	20x22 in., 450 hp.	Main units	200 r.p.m., condensing, 160 lb. steam, 125 deg. superheat	$8,000	Ames Iron Works
2	Generators	Alternating	250-kv.-a.	Main units	200 r.p.m., 2,200 volts, three-phase, 60-cycle		General Electric Co.
1	Switchboard	Direct and alternating current	6-panel	Current control			General Electric Co.
1	Motor	Induction	20-hp.	Driving service pump	2,200 volts, 1,150 r.p.m.	5,750	General Electric Co.
1	Motor	Induction	50-hp.	Driving air compressor	2,200 volts, 1,200 r.p.m.		General Electric Co.
1	Motor	Induction	10-hp.	Driving air pump	Direct-connected, 600 volts		General Electric Co.
2	Generators	Direct-current	12-kw.	Exciter units	Belt-driven, 600 r.p.m., 125 volts		General Electric Co.
2	Boilers	Water-tube	174-hp.	Steam generators	160 lb. steam, 125 deg. superheat	5,500	Babcock & Wilcox Co.
2	Superheaters	Babcock & Wilcox		With boilers	100 to 125 deg. superheat		Babcock & Wilcox Co.
1	Heater	Open	500-hp.	Heating boiler-feed water	Using exhaust steam		Platt Iron Works
1	Pump	Duplex		Boiler-feed water	160 lb. steam	670	Platt Iron Works
1	Pump	Centrifugal	500 gal. per min.	Circulating water	Motor-driven		Platt Iron Works
1	Condenser	Surface	1,700 sq.ft. cooling surface	With main engines	26 to 28 in.-vacuum		Alberger Pump & Condenser Co.
1	Pump	Centrifugal, 2-stage	4-in.	Service pump	Motor-driven, 170 ft. head	2,400	Alberger Pump & Condenser Co.
1	Pump	Vacuum, wet	8x14x12-in.	With surface condenser	160 lb. steam		Alberger Pump & Condenser Co.
15	Nozzles	Spray, stationary	2-in.	Cooling circulating water		225	Spray Engineering Co.
1	Compressor and well fittings	Air	12x7½x12-in.	Pumping well water	Motor driven, air pressure 93 lb	1,991	Ingersoll-Rand Co.
1	Compressor	Air (old)	18x12x12-in.	Pumping well water	Steam-driven		Ingersoll-Rand Co.
2	Pumps	Compound (old)	10, 16 and 8 x 12 in.	Service, pumping from reservoir to town			Stilwell-Bierce Co.
1	Pump	Duplex (old)		Boiler-feed	Steam 160 lb.		Stilwell-Bierce Co.
	Steam and water piping					3,279	Crane Co.
	Setting boilers					1,140	Rust Engineering Co.
	Pipe covering					80	Cary Co.
	Brick, lime cement, tools, lumber, etc					4,237	
	Labor					2,259	
	Superintendent of Construction					1,997	
	Engineering					1,400	
					Total	$38,928	

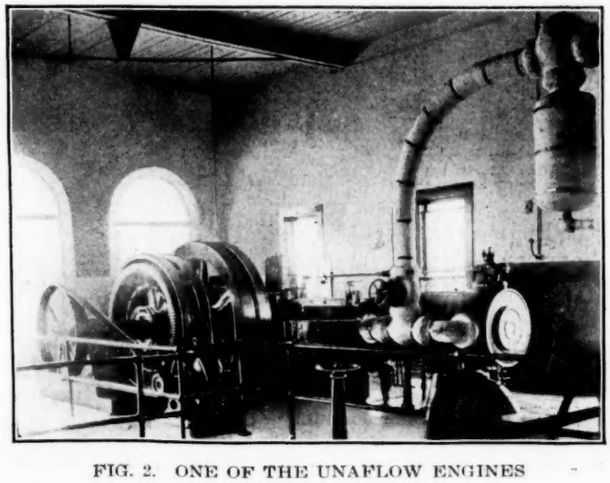


FIG. 2. ONE OF THE UNAFLOW ENGINES

The Cause of Many Boiler Accidents is the lighting of fires in empty boilers. The night watchman is not a boiler attendant and merely does as he has been told and lights the fires. If the water has leaked out of the boiler over night he may either not know the significance of an empty gage-glass or not feel competent to test it and to refill the boiler. When the fireman arrives and finds the boiler empty, the damage will have been done and the factory will have to be stopped while the leaky seams and rivets are being recalked.—C. E. Stromeyer.

Mixing Air and Furnace Gases

By S. H. Viall

SYNOPSIS—An analysis of seven series of tests showing the effect of incomplete mixing of the volatile with air and the variation in efficiency due to unburned gases escaping up the stack.

In the last article,[1] the action of the gases distilled in a soft-coal furnace was explained and it was pointed out that stratification of these gases and the air supply prevented the thorough mixture so necessary for complete combustion. To show that this stratification does exist, reference will again be made to the five series of tests referred to in previous articles. In Figs. 1 to 5 the furnaces are reproduced, and in Table 1 are given the averages of gas analyses and other data for the five series of tests, A, B, C, D and E, which were made in respective order on the five furnace constructions shown.

Because of less headroom and floor space required, together with lower first cost and upkeep, furnaces set flush front, as in the C, D and E series, have been more generally used than the full-extension dutch oven used in the A and B series. The results in the C, D and E series show that high CO_2 without CO is not a positive indication of high efficiency. These tests have been

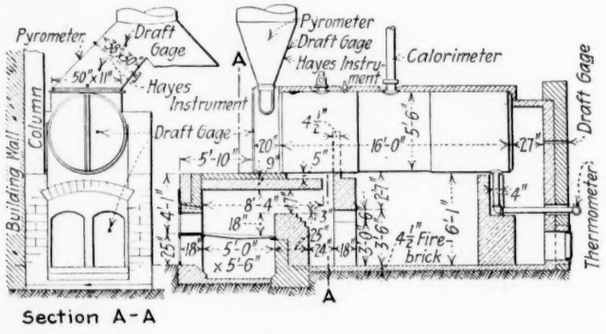


FIG. 1. FULL EXTENSION, TWO-SPAN DEFLECTION ARCH SETTING

selected primarily because they were all made upon the same boiler under conditions that make them comparable with one another. The efficiencies are low for reasons previously explained.

Referring to Table 1, it will be noticed that the average of the combined furnace and boiler efficiency of the E tests is 2.6 points better than for the C tests, even though the CO_2 was 0.6 point lower and the uptake temperature 16 deg. higher.

The distribution of the heat in B.t.u. per lb. of coal as fired is given in Table 2, while Table 3 presents the same information on a percentage basis. Referring to Table 3, it will be seen that the heat lost up the stack was 25.63 per cent. for the C series, 26.49 per cent. for the D series and 26.94 per cent. for the E series. In the same order the heat lost in the ashpit was 2.77, 4 and 5.36 per cent. The heat lost but accounted for thus totals 28.4, 30.49 and 32.3 per cent. respectively. Series C has the highest CO_2, the smallest heat loss accounted for and the lowest efficiency. Series E has the lowest CO_2, the largest heat loss accounted for and the highest efficiency. The corresponding figures for the D series are approximately an average of the other two.

Samples of the gases in the five series were taken from the breeching at a point above the damper plate. The brick setting, which was five years old and cracked, permitted considerable air infiltration. Undoubtedly the percentage of CO_2 was between 2 and 4 points higher in the combustion chamber at the end of the flame. Whatever the infiltration was, it is reasonable to assume that it was practically constant for equal draft over the fire. The CO_2 figures are therefore a relative indication of the conditions at the end of the flame.

Middle-Western coal was used averaging 10,857 B.t.u. per lb. as fired. Average ultimate analysis of the coal showed approximately 4.12 per cent. hydrogen as fired. Burning this amount of hydrogen would liberate 2,654 B.t.u., which is 24.5 per cent. of the heat of the coal as fired. The coal was hand-fired one to eight shovelfuls at a time, without any set regularity between firing periods. The major part of the distillates were driven off less than two minutes after the coal entered the furnace. It was during the periods of heavy distillation immediately following a fresh fire that losses would occur, owing to stratification of the combustible gas. With the plain setting used in the C series, the unaccounted-for losses were 17.7 per cent. of the heat supplied. In the D series on Fig. 4, the gases made two additional right-angled turns in passing from the fire to the rear end of the boiler. This turning of the gases brought about a better mixture, and the unaccounted-for losses decreased to 14.41 per cent. The stack and ashpit losses were greater, but the decrease in unaccounted-for losses resulted in a net gain in efficiency of 1.2 points.

Furnace Temperature Too Low

Spreading a quantity of fresh coal over a fire cools off the furnace. The temperature above the fire for a few seconds may drop below the ignition point of some of the distillates. This will often occur where the heat-absorbing surface of the boiler is directly over the fire, as with a common furnace and return-tubular boiler. The temperature drop may be sufficient to retard, although not stop, distillation. Particles of liquid oil will continue to be driven off from the coal. The heat in the open furnace above the fire may not be sufficient to evaporate all of the oil and raise the resulting gas to an igniting temperature. In an effort to overcome these difficulties the double-arch construction, Fig. 5, used in the E series was developed.

The function of the brickwork in the double arch and the deflection arch is to cause the furnace gases to dip and turn in a way similar to steam passing through a plain baffle separator. Many of the minute spheres of oil are precipitated upon the brickwork in the same way water particles are left in the separator by the passing steam. In addition to trapping much of the oily mist and holding it until gasified, the special brickwork tends to maintain, above and to the rear of the bridge-wall, a zone of more even temperature than is found in the furnace above the fire. When the brickwork is hotter than the passing gases, it will heat them, causing much of the

[1] "Power," Apr. 25, 1916, p. 579.

combustible material to ignite. The double arch between the deflection arch and the front face of the bridge-wall thus materially assists in the burning of the fuel.

Exposing the fire on the grates to the cooling influence of the boiler shell, as in Figs. 3 to 5, lowers the average furnace temperature below that obtained in a firebrick-

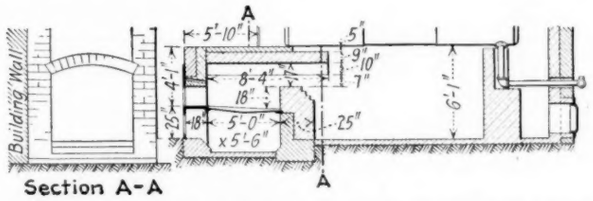


FIG. 2. SAME AS FIG. 1, BUT WITH DEFLECTION ARCH REMOVED

inclosed furnace. With a lower furnace temperature, the heat does not penetrate the freshly charged coal as quickly and the distillates are not driven off as rapidly. The distillation is therefore more uniform, allowing more time to get air into the furnace for burning the combustible gases.

The unaccounted-for losses in the E series were 3.2 points less than in the D series and 6.5 points less than in the C tests on the plain furnace. The losses accounted for were greater, yet the efficiency was better. This shows that the double arch and the deflection arch are a benefit and do to some degree effect the purpose for which they were provided.

Inspection of Figs. 1 and 2 shows that a deflection arch was used during the A tests and an open-end furnace during the B tests. The unaccounted-for losses, as given in Table 4, are 21 and 13.39 per cent. respectively. In the latter case the gases make only one right-angled turn between the fire and the rear end of the combustion chamber, as compared to three turns when the deflection arch was used. These results do not check apparently with previous statements to the effect that turning the gases betters the mixture and reduces unaccounted-for losses, but may be explained.

During the A tests a thin fire was carried and holes would frequently burn through, allowing excess air to

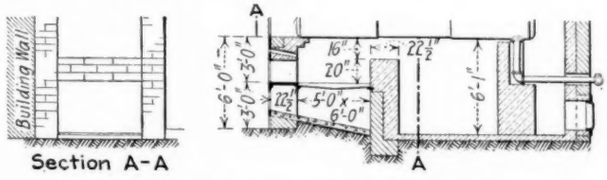


FIG. 3. PLAIN OR COMMON SETTING

pass. Radiation from the brick roof and sides of the furnace caused a distillation of almost explosive violence when fresh coal was supplied. There were therefore alternate periods of excess air followed by shortage of air during distillation. That the excess air was not serious is shown from the CO_2 readings. That the shortage of air during distillation was serious is shown by the unaccounted-for losses, which amounted to 21 per cent.

During the B tests the fires were carried a little thicker and the fire-doors were left open a few inches for a few seconds to a minute or so after each firing. The partly open fire-doors permitted more air to enter the furnace than usual, and it was admitted when most needed. Although no special provision had been made for mixing the combustible gases and air, the decrease in unaccounted-for losses would indicate that much of the volatile combustible had been oxidized.

It may be thought that such variation in losses can occur only in a badly operated hand-fired plant. To show that these losses will occur in the best plants, tests F and G have been added to the tables. These data are from

TABLE 1. ANALYSES OF STACK GASES AND COAL, AND OTHER DATA

Series	A	B	C	D	E	F	G
Type of furnace, Fig. No.	1	2	3	4	5	..	..
Combined boiler and furnace eff., per cent	50.20	57.50	53.90	55.10	56.50	72.67	72.55
Carbon dioxide, per cent	8.90	9.40	9.20	9.10	8.60	11.48	12.70
Carbon monoxide, per cent	0	0	0	0	0	0	0.06
Oxygen, per cent	10.80	10.20	10.50	10.40	11.10	7.49	5.90
Nitrogen, per cent	80.30	80.40	80.30	80.50	80.30	81.03	81.34
Temp. of uptake gases, deg. F.	611	672	665	678	681	430	549
Temperature of steam, deg. F.	333	335	336	343	335	367	369
Diff. between uptake and steam temp., deg. F	278	337	329	335	346	63	180
Dry stack gases per lb. carbon, lb	27.95	26.52	27.08	27.36	28.89	21.88	19.77
Dry stack gases per lb. coal as fired, lb	15.65	14.98	15.81	15.23	15.55	11.35	12.00
Coal as fired, per sq.ft. grate per hr., lb	22.63	24.62	24.70	24.80	26.60	22.70	35.70
Draft over fire, in. of water	0.116	0.113	0.226	0.226	0.245	0.090	0.220
Coal per sq.ft. of grate per hr. per 0.01 in. of draft, lb	1.95	2.18	1.09	1.10	1.08	2.52	1.62
Moisture in coal as fired, per cent	15.40	16.30	10.10	11.30	10.90	15.90	15.20
Combustible in coal as fired, per cent	73.50	73.32	76.77	73.89	75.02	70.75	70.72
Ash in coal as fired, per cent	11.10	10.38	13.13	14.81	14.08	13.35	14.08
B.t.u. per lb. coal as fired	10,674	10,716	11,225	10,618	10,728	9,872	10,032

TABLE 2. DISTRIBUTION OF B.T.U. IN POUND OF COAL AS FIRED

Series	A	B	C	D	E	F	G
Type of furnace, Fig. No.	1	2	3	4	5	..	..
B.t.u. in lb. of coal	10,674	10,716	11,225	10,618	10,728	9,872	10,032
Absorbed by boiler	5,358	6,162	6,050	5,851	6,061	7,174	7,278
In dry stack gases	2,051	2,179	2,250	2,208	2,261	983	1,385
In superheated steam formed from burning H of coal	455	478	496	458	488	402	432
In superheated steam formed from moisture in coal	196	212	131	146	141	183	189
In unburned CO	0	0	0	0	0	0	29
Total accounted for up the stack	2,702	2,869	2,877	2,812	2,890	1,568	2,035
In ashpit (unburned carbon)	373	251	311	425	575	39	280
Radiation, unburned hydro-carbons and misc. unaccounted for	2,241	1,434	1,987	1,530	1,202	733	437

TABLE 3. DISTRIBUTION OF B.T.U. IN POUND OF COAL AS FIRED, IN PERCENTAGES

Series	A	B	C	D	E	F	G
Type of furnace, Fig. No.	1	2	3	4	5	..	..
Percentage total B.t.u. in pound of coal	100	100	100	100	100	100	100
Absorbed by boiler	50.20	57.50	53.90	55.10	56.50	72.67	72.55
In dry stack gases	19.21	20.33	20.04	20.88	21.08	9.96	13.82
In superheated steam formed from burning H of coal	4.26	4.46	4.42	4.31	4.55	4.07	4.31
In superheated steam formed from moisture in coal	1.84	1.98	1.17	1.38	1.31	1.85	1.88
In unburned CO	0	0	0	0	0	0	0.28
Total accounted for up the stack	25.31	26.77	25.63	26.49	26.94	15.88	20.29
In ashpit (unburned carbon)	3.49	2.34	2.77	4.00	5.36	0.39	2.79
Radiation, unburned hydro-carbons and misc. unaccounted for	21.00	13.39	17.70	14.41	11.20	11.06	4.37

TABLE 4. SUMMARY OF HEAT DISTRIBUTION IN PERCENTAGES

Tests	A	B	C	D	E	F	G
Figure No.	1	2	3	4	5		
CO_2	8.90	9.40	9.20	9.10	8.60	11.48	12.70
Heat absorbed by boiler	50.20	57.50	53.90	55.10	56.50	72.67	72.55
Heat losses accounted for	28.80	29.11	28.40	30.49	32.30	16.27	23.08
Heat losses unaccounted for	21.00	13.39	17.70	14.41	11.20	11.06	4.37
Total heat	100	100	100	100	100	100	100

two tests upon a 300-hp. vertically baffled horizontal water-tube boiler equipped with a chain-grate stoker. Illinois screenings were used for fuel. The construction of the plant and the general care and skill of operation were unusually high-class. The men conducting the tests knew about what efficiency could be expected from the unit with certain uptake temperatures and gas analyses.

During the F test the uptake temperature was 119 deg. lower than in the G test. The CO_2 was almost as high and there was no CO. The men could see that the ashpit loss was going to be very low. Judging from observed conditions and past experiences, they estimated a combined efficiency of 75 to 77 per cent. When the heat balance was calculated, they were surprised to find that the unaccounted-for losses were more than 11 per cent.;

about 5 per cent. or less was expected. After careful study they finally concluded that from 4 to 6 per cent. of the heat was in the unaccounted-for losses in the form of unburned hydrocarbons.

The volatile was distilled at the front end of the furnace. The gases rose to the arch over the grates, following back to the opening between the end of the arch and the bridge-wall. Then they turned upward into the tube region. During the F test the draft over the fire was exceptionally low for the rate at which the coal was being burned. The velocity of the air entering the furnace was therefore low. The furnace proportions were such as to permit of sluggish movement of the gases as they passed under the arch and through the furnace outlet. This, together with the low velocity of the entering air, resulted in part of the hydrocarbon gases reaching a zone below their ignition temperature before mixing with the air.

That these conclusions are reasonable is shown by the data given in test G, which was made on the same unit. During this test the draft over the fire was stronger and the gas volumes handled larger. This resulted in higher velocity of furnace gases and in better mixtures. During the G test 80 per cent. more steam was made and 6.8 per cent. more heat is accounted for as lost up the stack or in the ashpit, yet the percentage of heat absorbed by the boiler was practically the same as in the F test.

In Table 1 are given data relative to the weight of dry stack gases per pound of coal as fired. In Tables 2 and 3 are given the heat losses due to evaporating the moisture in the coal. These figures are interesting as

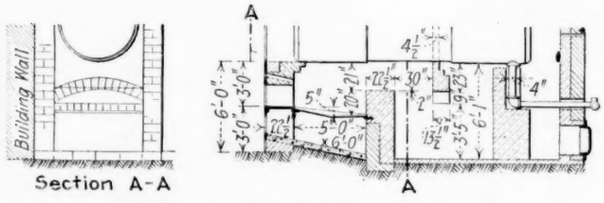


FIG. 4. PLAIN SETTING WITH DEFLECTION ARCH

they show the weight of stack gases per pound of Illinois or Indiana coal as fired. They also show that the heat loss due to the moisture in the coal is not so important in comparison with other items as some seem to think.

Burning volatile coal at high rates of combustion has presented many problems, not the least interesting of which is that of securing proper mixture of distillates and air supply. The discussion here presented is not by any means the final word on the subject. If it has been of interest and causes some study to be given to smokeless combustion, it will have served its purpose. In closing, two instances that bear upon the subject will be related.

Some years ago there was a plant that had three 300-hp. Stirling boilers with the typical Stirling settings. The fuel was sawdust and shavings from kiln-dried lumber chute-fed from cyclone heads. The fuel bed on the grates varied in thickness from 12 to 30 in. and averaged about 18 in. Shavings came over with regularity, and there was little need to disturb a fire except to level off about once every half-hour. The stack was brick and 175 ft. tall. The fire-doors were kept closed. Only a little air worked its way up through the thick bed of shavings on the grate. Most of the air-supporting combustion came down through the shaving chutes. The heated fire-brick walls and Stirling arch distilled the volatile from the shavings. Part of the distillate was burned, but much of it passed up the stack. After dark a long dull-red flame, like a torch free from sparks, could be seen streaming from the top of the stack. This flame often was visible for hours at a time. Opening the fire-doors and knocking away the shavings in front of it so as to admit air over the fire would stop the flame at the top of the stack. The men learned to open the fire-doors to a certain point when they wanted more steam and to shut

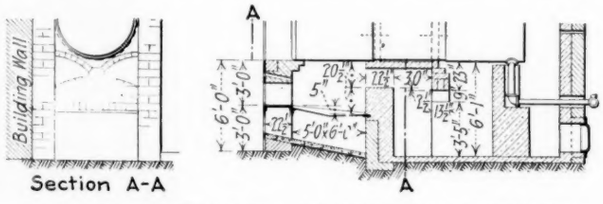


FIG. 5. DOUBLE-ARCH BRIDGE-WALL FURNACE

the fire-doors when the pressure was high. Looking in a hole in the breeching between the boilers and the stack, one saw no flame and comparatively few sparks.

In another plant there were two large-tube boilers under a stack 90 ft. high. Rich high-volatile coal was used for fuel. The furnaces were hand-fired. The gases made one vertical pass from the fire across the tube region into the base of the stack. There were three fire-doors to each furnace. The practice was to fire through each door in rotation until the entire area of both fires had been covered with from 4 to 6 in. of fresh coal. After dark, following each firing, a dull-red flame could be seen streaming away from the stack. The flame would continue for a few seconds to several minutes at a time. In both cases the stacks smoked furiously.

These stories are not told because they are unusual, but to prove that hydrocarbon gases pass up the stack unburned. They illustrate what is happening on a smaller scale in many furnaces that are being forced.

Heat Value of Fuels

Kind of Fuel	Heat Units per Lb.	Relative Values	Lb. of Water Evaporated per Lb.
Carbon, pure	14,500	1.000	15.00
Hydrogen	62,500	4.280	62.75
Marsh gas	26,415	1.816	26.68
Olefiant gas	21,328	1.466	21.54
Coal, anthracite	14,833	1.020	14.98
Coal, bituminous	14,796	1.017	14.95
Coal, lignite dry	10,150	0.7	10.35
Peat, kiln dried	10,150	0.7	10.25
Peat, air dried	7,650	0.526	7.73
Wood, kiln dried	8,029	0.551	8.10
Wood, air dried	6,385	0.439	6.45
Charcoal	13,500	0.93	14.00
Coke	13,620	0.94	14.00
Petroleum, W. Va.	18,300	1.255	18.80
Petroleum, Penn.	18,050	1.24	18.60
Petroleum, Ohio	18,450	1.27	19.05
Petroleum, Asia	18,000	1.24	18.60
Petroleum, Europe	18,000	1.24	18.60
Animal fat	9,000	0.65	9.30

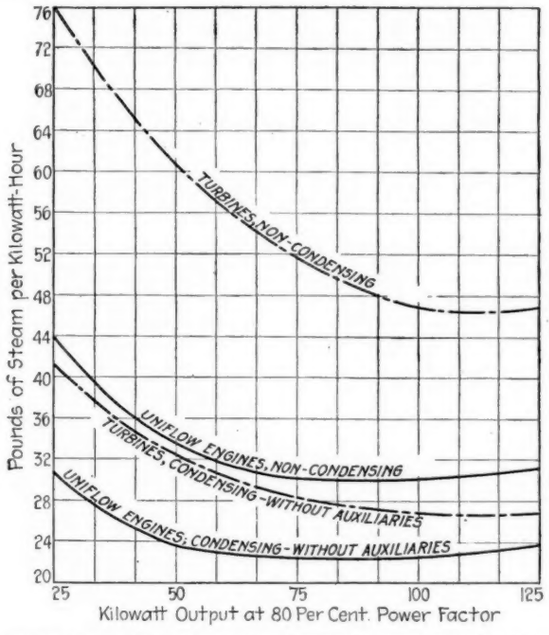
Interesting Results of a Locomotive Test—The coal consumed per hour during a test of a locomotive in the laboratory of the University of Illinois was at the rate of 224.5 lb. per sq.ft. of grate, in a firebox 5½x9 ft., an area 49.5 sq.ft. The draft in the smoke box caused by the exhaust blast was equal to 12.8 in. of water, and the cinder ejected amounted to 27.4 per cent. of the dry coal. The water evaporated with 11,800 to 12,850 B.t.u. coal, to 200-lb. steam pressure, was 17.6 lb. per sq.ft. of heating surface—189 sq.ft. in the firebox and 3,094 in the tubes, or 1,170.8 lb. per hr. per sq.ft. of grate. The apparent equivalent evaporation was 10.7 lb. of water per pound of dry coal, and as the maximum horsepower developed was 1,654 and the lowest rate of steam consumption was 27.17 lb. per i.hp., the coal per indicated horsepower was 4 lb., slightly more than in other tests of this type of locomotive.

Performances of Uniflow Engine and Turbine Compared

By L. A. Quayle*

SYNOPSIS—To determine which type of unit would furnish light and power most economically for the three million dollar pumping station and filter plant now being completed by the Water Department of Cleveland, bids were received on both uniflow and turbine-driven generating units.

The prices and economy guarantees received on bids from two engine and three turbine builders, as well as informal bids received from two other companies, one a turbine and the other an engine builder, have been used in making the comparisons given here. The prices and guarantee curves represent only the average of three makes of engines and four makes of turbines, including



TURBINE AND UNIFLOW ENGINE PERFORMANCE CURVES

three different makes of generators, all of the bidders being well known.

It is felt that the economy guarantees are conservative, as there was a penalty of $700 per pound of steam per kilowatt-hour for failure to meet the guaranteed economy, and no bonus was offered for exceeding the guarantees.

One unit only was to be purchased, as the municipal electric light current was available for paralleling on heavy overloads or could take the entire load in the event of accident to the engine. The unit is to operate either condensing or noncondensing, depending upon the demand for exhaust steam for heating the buildings and feed water. The demand for exhaust steam for heating varies, of course, with the time of year, the season lasting about seven months.

*Mechanical engineer, Cleveland Water Department.

The following steam and electrical conditions were specified:

Generator size	100 kw. at 80 per cent. power factor
Temperature rise under above load	40 deg. C.
Current characteristics of generator	3-phase, 60-cycle, 240-volt
Type of exciter	125-volt—7-kw. mounted at end of generator shaft.
Steam pressure at throttle	200 lb. gage
Superheat	100 Deg. F.
Back pressure running noncondensing	2 lb. gage
Vacuum	26 in. for engine 28 in. for turbine
Average cooling water temperature	53 deg. F.

The average water-rate guarantee curves are shown. The engine units have an average full-load condensing water rate approximately 15.7 per cent. lower than the turbo-generators, and an average full-load noncondensing water rate 35.6 per cent. lower. On loads less than full the engines become relatively still more efficient, until at one-quarter load, noncondensing, they consume only 58 per cent. as much steam as was required by the turbo-generators.

In comparing these water rates with other alternating-current units, it should be noticed that these guarantees include all electrical losses of generator and exciter at 80 per cent. power factor, as well as the losses in the field rheostat used for paralleling. That it is important to consider these is shown by Table 1.

TABLE 1. ELECTRICAL EFFICIENCIES

Kw. output	25	50	75	100	125
Generator efficiency 100 per cent. power factor	81.3	88.5	91.2	92.3	92.8
Generator efficiency 80 per cent. power factor	78	85.4	87.5	88.5	89.0
Combined generator and exciter efficiency at 80 per cent. power factor	75.7	85.0	87.3	88.0	88.2
Combined generator and exciter efficiency at 80 per cent. power factor including field rheostat losses	72.5	82.5	86.2	87.6	88.2

The engine unit would deliver 100 kw. to the switchboard with a steam consumption of 21.4 lb. per kw.-hr., which is considerably less than the 22.5 lb. per kw.-hr. required to deliver 100 kw. under conditions of 80 per cent. power factor with exciter and rheostat losses included. This shows the importance of specifying clearly all conditions that the bidders are to consider, as the capitalized difference in value between units having the apparent water rates of 21.4 and 22.5 lb. is 1.1 $\times$ 700 = $770. If the buyer merely asked bidders to state the water rate under the foregoing steam conditions, two dealers bidding on the same engine might guarantee different water rates and both be right for the conditions they assumed.

Assuming a fuel cost of 11c. per 1,000 lb. steam with the unit generating 1,525 kw.-hr. per 24 hr. day, operating 6 hr. at ¼ load, 6 at ½ load, 7 at ¾ load, 3 at full load, and 2 at 1¼ load, which represents the distribution of the loads as closely as can be determined, the daily fuel cost would be shown in Table 2. As the cost of cylinder oil for the engine would be approximately 9c. per day, it has also been included.

As the bearing lubricating oil for either type of unit is supplied from a large central oiling and filtering system, it is assumed that the bearing lubricating cost would be the same for both types.

On account of the undesirability of operating the very small condenser auxiliaries on 200 lb. steam pressure, Table 2 is based on the use of motor-driven, air, condensate and circulating pumps for both turbine and engine units. These auxiliaries for either type of unit are assumed to require an input of 4 kw. at all main unit loads. This assumption favors the turbine somewhat owing to the larger quantity of steam and circulating water handled by the turbine auxiliaries.

TABLE 2. DAILY FUEL AND OIL COSTS

Unit	Daily Fuel Cost	Extra for Cyl. Oil	Total Fuel and Cyl. Oil per Kw.-Hr.
Engine running condensing, including auxiliaries	$4.21	$0.09	0.28c.
Turbine running condensing, including auxiliaries	5.28	0	0.35c.
Engine running noncondensing	5.41	0.09	0.36c.
Turbine running noncondensing	9.06	0	0.59c.

The average cost of the turbo-generator and engine-driven units erected complete and ready for service, with surface condenser and auxiliaries for condensing units, is shown in Table 3. These prices include circulating-water supply piping, also the oil separator and trap, and extra floor reinforcing for the engine unit, which items will be furnished by the city.

As the unit will consume less than 5 per cent. of the total steam generated at the station, no capital or labor charges for the boiler plant have been added. The comparative yearly cost of both types of units operating condensing and noncondensing, as given in Table 3, assumes no cost for circulating water except interest on the circulating-pump investment and on the power required to drive the pump.

TABLE 3. COMPARATIVE YEARLY COSTS

	Engine Units		Turbo-Generators	
	Condensing	Noncondensing	Condensing	Noncondensing
Average cost of unit erected complete with auxiliaries for condenser unit	$6,625	$5,525	$6,090	$3,981
Yearly fixed charges, interest 5 per cent., depreciation 8 per cent.	861	718	792	518
Yearly fuel cost for steam at 11c. per 1,000 lb., 360 days, 24 hr. operation	1,516	1,948	1,901	3,262
Yearly cyl. oil cost at 18.6c. per gal., engine using 2 qt. per day	25	25	0	0
Yearly fixed charges, steam and oil cost	$2,402	$2,691	$2,693	$3,780

The table is based on the further assumptions that there is a surplus of exhaust steam in the station, from the boiler feed pumps, etc., which can be used to heat the condensate from the condensing units to 210 deg., and also that the exhaust steam from the noncondensing units in excess of that required to heat the feed water for the units from 53 to 210 deg. is wasted.

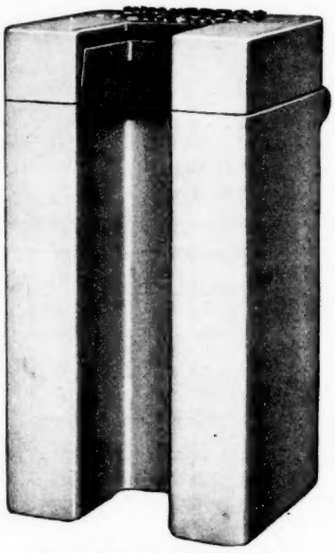
These assumptions favor the condensing units materially, but in spite of this the noncondensing engine has a lower total yearly cost than the condensing turbines, if circulating water costs anything.

For all installations that depend on the city water supply for condenser circulating water, the noncondensing uniflow engine would show a material saving over the condensing turbine. The turbine would require approximately 174,000 gal. per day, and if 3 per cent. of this water evaporated while cooling, the yearly cost of water would be over $100, paid for at the rate prevailing in Cleveland, namely 5⅓c. per 1,000 gal. To the cost of the water the interest on the investment of a cooling tower should also be added.

If, however, most of the exhaust steam can be used for heating or manufacturing processes, the noncondensing turbine would probably be the most economical purchase. In making comparisons of this kind so many assumptions have to be made that it is useless to draw conclusions regarding the relative merits of these two different types of generating units. It is felt, however, that enough data have been given to enable the average purchaser to determine which type of unit, if approximately of this size, would be the most economical to purchase

Elevator-Guide Lubricator

The elevator-rail lubricator illustrated herewith is an oil box cast from an aluminum alloy of ⅛ in. thickness and contains no inside movable parts except the three pairs of wicks, of specially prepared material, designed with a view of preventing the glazing or caking over of the surfaces. The wicks wipe off the edges and both sides of each rail and at the same time deposit the requisite quantity of oil upon the cleaned surfaces. The feed is positive, and no oil is delivered except when the elevator car is running. The wicks are secured in place by two screws through each pair. When they become worn, the screws can be removed, the wicks pulled up to a new position and the screws replaced. The only spring about the device is one on the hinge of the lid to keep it closed tightly.

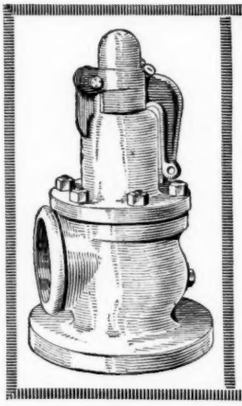


LYNE GUIDE LUBRICATOR

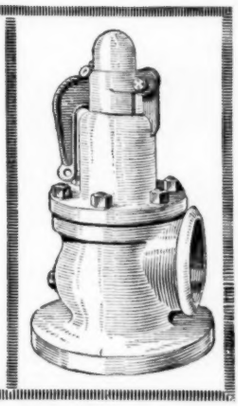
Each box has a suitable support or bracket for attaching it to various types of elevator cars. The box can be attached to the counterweights as well as to the car proper. It is manufactured by Lewis F. Lyne, 39 Cortlandt St., New York City.

Loss of Heat by Radiation varies with the difference in temperature between the steam and the surrounding medium, the insulating quality or low conductivity, of the covering and the amount of the exposed area. Variations in detail in different plants vary the monetary loss by radiation, but some idea of the magnitude of this loss in one plant may be gained from the statement that by the proper insulation of a pipe having an area of 65 sq.ft., carrying steam at 150 lb. pressure, with a room temperature of 65 deg. F., the condensation has been reduced from 74.40 to 11.58 lb. per hour. With coal at $4 per ton and with an evaporation of 11 lb. of water per pound of coal, this would be equal to a saving of over $33 per year, or about 50c. per year for each square foot of pipe.

Clearance Travel in a Steam or Ammonia Cylinder may be determined by inserting a piece of lead or soft-solder wire between the piston and the head so that it will be flattened between at the end of the stroke. The amount of clearance is then found by a micrometer. This thickness of the flattened wire expressed in fractions of an inch, divided by the stroke in inches, gives the percentage of clearance. If the volume of the clearance space is to be determined, the machine is turned over so that the piston stands at the end of the stroke, the exhaust valve is closed, and the space is filled with oil. This gives the volume or total clearance. As a check the oil should be measured both as it goes in and as it is drawn out of the cylinder.



Why Safety-Valve Seats Are Beveled



By Charles H. Bromley

SYNOPSIS—Many well-known manufacturers tell why. Most of them believe that custom is responsible for the extensive use of the 45-deg. seat.

Among engineers of all grades a question one hears asked as often as any other is, "Why are the edges of safety valves beveled and what are the advantages over a flat-seated valve?" In many safety-valve specifications one sees it stated that the seat or disk shall have an angle of 45 deg. with the axis of the valve. For some reason examiners of applicants for engineers' licenses use this as one of the stock questions. At the meetings of engineers' societies this question comes up with the frequency of the meetings and as regularly as though it were the password.

So why are the edges beveled anyway? The writer believed the makers of safety valves should know and wrote asking them to state their reasons in *Power*. They follow:

Albert C. Ashton, of The Ashton Valve Co.: Safety valves are almost universally made with 45-deg. bevel seats because this design has proved, by long experience, to give the best service. Seats that are made to an angle of more than 45 deg. with the vertical axis of the valve offer more of an obstruction to the free escape of the steam and as a consequence are more likely to hold back any foreign matter, such as chips and packing, that might be discharged with the steam; and further, these will create more damage to the flat seat. On the other hand, seats that are made at a less angle than 45 deg. have a much greater tendency to stick fast by wedging themselves in too tightly. Horizontal flat seats, which would be at an angle of 90 deg. with the valve axis, offer some advantages to the bevel seats, in that they give an opening corresponding to their lift, whereas the 45-deg. seats only give an opening of $\frac{7}{10}$ that of the lift, but we have found flat seats in other respects undesirable as they do not wear so well and give much more trouble from leaking.

W. E. Jerauld, of the American Steam Gauge and Valve Manufacturing Co.: We know of no particular advantage that a seat beveled to an angle of 45 deg. has over the type known as the flat seat, or which is at an angle of 90 deg. to the axis of the valve.

The 45-deg. beveled seat has been more commonly used, we believe owing to the fact that in the history of the manufacture of safety valves before the pop style of valve came into general use, the 45-deg. beveled seat was more generally employed, and it has since then become the custom, which in our opinion is the real reason for its being more extensively used.

John E. Lonergan, of the J. E. Lonergan Co.: We have made many safety valves with 30-deg. seats, also 45-deg. seats, as well as flat seats, all giving equally good results in service. The 45-deg. seat is probably more extensively used, not because of any particular advantage over the other forms, but merely because the first makers adopted that angle and others followed their practice, as no bad results were experienced with low pressures that prevailed until recent years.

It is not unusual, especially in marine service, to carry 280 lb. per sq.in. I prefer the flat-seat valve, because any spring in the valve seat liable to occur under high pressure does not affect a flat seat as disadvantageously as it does the 45-deg. seat, and consequently the former is more easily kept tight. A flat seat will discharge approximately as much steam under a given pressure at $\frac{7}{100}$ in. lift as a 45-deg. seat will discharge at a lift of $\frac{1}{10}$ in., so that the closing of a flat-seat valve is not so severe, because of its small lift with equal discharge capacity as compared with a 45-deg. seat at a higher lift.

Therefore the lower-lift valve with a maximum discharge has a longer life in service without repairs than the higher-lift valve.

This is the writer's experience extending over more than a quarter of a century.

The Lunkenheimer Co.: We cannot, in the brief time allowed, cover the point as comprehensively as you probably would like, hence our answer will of necessity be quite brief.

Tightness of seat is a vital feature, and this is more practically assured for general service in the bevel type. A 45-deg. bevel is preferred to any other angle because while it affords greater wedging power than a lesser-degree bevel, it at the same time avoids the possibility of sticking, which a sharper angle would be subject to.

When discharging, the force of the steam acting against the disk lip and the reaction upon the stationary member is more direct and effective than it is in a flat-seated valve. Other means may be provided to offset this, but at the expense of added cost or the disadvantage of a design that is very difficult to manufacture.

A. B. Carhart, of the Crosby Steam Gage and Valve Co.: Your inquiry, "Why are the edges of safety-valve

seats beveled at 45 deg.?" is an example of a simple question that is difficult to satisfactorily answer. The only explanation that can be given is, because this is an old custom that has been followed unquestioningly without any special reason. This answer hardly seems persuasive on its face, and so I have this morning telephoned to Prof. E. F. Miller, of the Massachusetts Institute of Technology, and he says the same thing. I afterward telephoned Mr. Jerauld, superintendent of the American Steam Gauge and Valve Manufacturing Co., here in Boston (because they have made safety valves in the past with both 45-deg. and flat seats), and he says that is the only reason he knows why 45-deg. seats are so common.

Early Valves Had Beveled Seats

My impression is that stop valves were made with bevel seat faces, so that the disk could be wedged tightly into its seat, long before safety valves were thought of. Of course the very earliest way of keeping closed the outlet of a flask or vessel in which boiling liquids were contained (as used by the alchemists) was to grind a taper stopper or conical plug into the opening. It is generally said that the first safety valve knowingly designed and used for the purposes of an automatic relief valve was devised by Denis Papin about 1685, in connection with the apparatus he invented for boiling bones. He found he had to use a higher pressure than atmospheric to get the temperature necessary to soften the bones, and he had difficulty in preventing explosions of these "digesters," so he used, on the top of the stopper in the retort, a lead weight that would be blown off if the pressure got too high.

Working from this start, it is easy to see that a conical seating face was natural. Yet when the lever and weight were put on the valve disk to regulate the opening pressure, the angle of the taper was probably reduced to 45 deg. instead of 60 or 80 deg. for example, to prevent the tendency of the disk or stopper from sticking or jamming in its seat. Some of the earliest relief valves had flat seats and were made simply like the cover of a teakettle, with the weight hanging on the knob; but some of the editorial staff of the *American Machinist* can tell you how very inaccurate the lathe work of those days was and how crude the machines were with which the seating operation likely had to be done. It was probably necessary that the seats and disks of stop and safety valves should be of such wedge or taper form that they could be ground in after they were in place. A 45-deg. bevel is not likely to stick because of jamming, from corrosion or expansion, and yet it has sufficient taper to grind down to a shoulder.

Flat Seat Tight as Beveled Seat

Early patents show valves with flat seats and valves with angular seats at 45 deg., and some steeper and some flatter. Flat seats probably were not common or popular in early valves, because of the careful workmanship necessary to make a tight seat all the way around. But in modern valves flat seats are certainly as tight and as satisfactory as any bevel seats. I know I have heard it said that flat seats will not keep tight, but there is absolutely no foundation for such a belief, and this assertion is always made by those who have not used flat-seated pop valves. (It may have started from the difficulty in keeping flat slide-valves in engines tight; but of course these are not analogous.)

The American Steam Gauge and Valve Manufacturing Co. more than ten years ago made pop valves with one flat seat, but I believe abandoned that because 45-deg. bevel seats were required in so many specifications then that it did not pay them to make both kinds. Certainly there was no fault with the valves nor was there any difficulty in making the seats tight as the reason for not continuing their manufacture. This was the only attempt, so far as we know, by anyone besides the Crosby company to make pop valves with flat seats, until within the past year or two the J. E. Lonergan Co., of Philadelphia, produced a safety valve with flat seats. Formerly the safety-valve specifications of the United States Navy required 45-deg. bevel seats; but nowadays they require seats "as near flat as practicable," and not to exceed 45 deg. The rules of the Board of Supervising Inspectors of Steam Vessels formerly approved only valves with 45-deg. seats, but they admitted freely they know of no reason why this had been done. Their rule on this point was drafted for them in 1903 by an engineer (L. D. Lovekin, chief engineer New York Shipbuilding Co.) familiar chiefly with marine practice, and undoubtedly he followed the custom more common in marine work, without any special reason. Their rules were amended two or three years ago to include either 45-deg. or flat seats. The Massachusetts Board of Boiler Rules specified 45-deg. seats in 1906, but frankly admitted it was done because the members were not familiar with flat-seated valves. The boiler rules in Massachusetts, Ohio, Wisconsin and other states and the new A. S. M. E. Boiler Code all approve flat seats as well as 45-deg. seats.

British Lloyds and Canadian Rules

Why the angle of 45-deg. was or is specified, no one can explain. The old rules of the British Lloyds and the recent boiler rules of the several Canadian provinces do not specify any angle for the valve seat. The Crosby company still makes valves ordinarily to meet navy and marine specifications with 45-deg. bevel seats; but the locomotive valves and other valves of the distinctive Crosby type have always had flat seats (and moreover, double, concentric seats), and we have never had any difficulty in making such valves tight or in keeping them tight. This is not a new idea, for Crosby valves made in this style have been manufactured for forty years continuously, since Crosby's first patent of this design. During the past 30 years more than 225,000 (by actual count) of these flat-seated valves (with double, concentric seats), in sizes 1-in. to 2-in., have been sold for use on farm engines in the West, Northwest, South America and Africa, and they have been is use all over the world, especially in the days before gasoline supplanted steam so largely in farming machinery. These valves have been necessarily in the hands of the most ignorant, unskilled and inexperienced operators and have given satisfaction. If valves of this type were not satisfactory or leaked even the slighest amount, they would not be in use today so largely on locomotives.

Some modern valves have the angle of the seat steeper than 45 deg. F. L. Fairbanks, chief engineer of the Quincy Market Cold Storage Co., in Boston, has some ammonia relief valves in service that have 60-deg. seats;

but the seating surfaces in these valves is very narrow, practically a knife-edge.[1] In any case, even when the seat faces of the valve disk and seat are comparatively wide, the actual steam-tight joint is simply a hair line. This sinuous line of steam-tight contact is not a true circle, but appears like a wavy line back and forth over the width of the valve seat, and the steam-tight line changes every time the disk is turned or ground.

It has been said that a 45-deg. bevel seat has an advantage, because when the spindle is fastened to the valve disk, the latter can be turned on its seat when a leak develops, and in this way ground to a tight joint. I believe that this was the custom in valves used on steam boilers at sea. But I think this is a fallacy and not as practical as it sounds, for a leak is usually due to small particles of scale or foreign matter lodging on the face of the valve seat, and the best way to clean the seat is to lift the valve by the lever and blow the foreign matter away. If the disk is forcibly turned upon the seat, the hard foreign matter scores the seat all the way around, and in most cases the leak is only made worse and then requires the valve to be taken off and the seats machined before they can be made tight. If bevel seats were easier to keep tight than flat seats, flat seats would not be so commonly used in valves for high pressures. Take high-pressure steel stop valves, the Hancock and the new Lunkenheimer brass globe valve, also the balanced-float water-regulating valve, for examples (certainly as different types as could be cited) and note the successful use of flat instead of bevel seats.

Mr. Eddy of the Consolidated Safety Valve Co. (by telephone): The 45-deg. seat is easier to make and easier to maintain tight. Scale or other matter blown out with the steam has a freer exit with the 45-deg. seat, and the foreign matter is less likely to remain on the seat or disk.

Impure Boiler Waters

By William N. Berkeley*

SYNOPSIS—The treatment of boiler waters, from rivers especially, should be based on many analyses during periods of drought and continued rains. Treating for temporary and for permanent hardness. Amounts of reagents to use for softening waters of known compositions. Good and bad waters.

Water condensed in the atmosphere and reaching the earth in the form of fog or rain contains practically nothing in solution other than the gases derived from the atmosphere, if it falls in places remote from habitations or of industrial establishments, such as crowd most of our large cities.

From the time it reaches the earth's surface, its composition is changing continuously, the rapidity of the change at any given time depending on prior changes, such as the solution of gases (carbon dioxide, sulphur dioxide, etc.) or of alkaline salts, such as sodium carbonate, by which its solvent action is increased, as it is also by increased temperature and pressure.

This variation of composition of natural waters is important when the question of purification or softening is considered, as a remedy based on the knowledge of the composition of water at a given time may not be suitable for a considerable time.

It is obvious that the percentage composition of water from a river flowing through a region in which there has been a protracted drought must be different from the water of the same origin after a period of excessive rainfall. In the case of river waters this variation in composition is great and may amount to as much as 100 per cent. from week to week. Decisions should not, therefore, be based on a single determination of the quality, but on a number made on samples taken at various times and periods of drought and of normal and excessive rainfall.

Substances that occur in such amounts as to cause trouble in boilers are limited, being confined chiefly to the carbonates and sulphates of calcium and magnesium, the chloride of magnesium and possibly, in exceptional cases, the chloride of calcium. These salts are generally classed as incrustants. Only the carbonates and sulphates of calcium and magnesium are serious. It is to the presence of the sulphates that the so-called permanent hardness of water is due most generally.

The carbonates of calcium and of magnesium are practically insoluble in water free from carbon dioxide (CO_2), but in the presence of this gas they pass into solution, probably as bicarbonates—that is $CA(HCO_3)_2$ and $Mg(HCO_3)_2$ respectively—though, according to some authorities, the solubility of the calcium and magnesium salts is due to their being in the colloidal state.

Whatever may be the reason of their solubility, they are both made practically insoluble by heating, for which reason the hardness caused by them is most readily removed in this way. Another method of removing this "temporary hardness" is to add calcium hydroxide (slaked lime) which combines with the free carbon dioxide, causing the precipitation both of the carbonates originally in solution and that formed by reaction between the free carbon dioxide or the water and the calcium hydroxide added. This reaction is expressed by the following equation:

$$Ca(HCO_3)_2 + Ca(OH)_2 = 2Ca\ Co_3 + 2H_2O$$

The removal of temporary hardness may be effected by a combination of heating and treating by calcium hydroxide. Owing to the greater solubility of the magnesium salt, the removal of this is less complete than that of the calcium; moreover, with the latter the precipitation is not complete, and water softened by the means just described may still have from two to three grains of calcium carbonate and a larger quantity of magnesium carbonate in solution.

Permanent hardness is caused, for the greater part, by calcium and magnesium sulphates and chlorides. Silica and the salts of iron might be added, though generally the amount of these is so small as to be negligible.

[1]For description of this valve see "Power," Nov. 30, 1915, p. 753.

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Although the solubility of calcium sulphate, the more important of the incrustants, increases with increased temperature from about 0.2 per cent. at 18 deg. to 0.21 per cent. at 38 deg., decreasing from this temperature, the temperature required for its elimination by this means is too high to make it practicable to remove it by heat alone, for even at 300 deg. F. its removal is not complete, and its elimination is generally effected by sodium carbonate (Na_2CO_3) or by caustic soda (NaOH).

Assuming that the water contains calcium sulphate, magnesium sulphate and magnesium chloride, the reactions occurring between these salts and sodium carbonate and sodium hydroxide respectively are expressed by the following equations:

$$CaSO_4 + Na_2CO_3 = CaCO_3 + Na_2SO_4$$
$$MgSO_4 + Na_2CO_3 = MgCO_3 + Na_2SO_4$$
$$MgCl_2 + Na_2CO_3 = MgCo_3 + 2\ MaCl$$

or, using sodium hydroxide (NaOH),

$$MgSO_4 + 2\ NaOH = Mg(OH)_2 + Na_2SO_4$$

and similar reactions for magnesium chloride. As the solubility of calcium hydroxide is considerable, the removal of calcium sulphate by sodium hydroxide would not be practical. From the foregoing reactions it is seen that each grain of calcium sulphate requires 106/136 of a grain of Na_2CO_3 and that each grain of magnesium sulphate requires 106/120 of a grain of Na_2Co_3, and magnesium chloride 106/95 gr. to precipitate them.

Amount of Soda-Ash Needed

The amount of precipitants—lime and soda ash (Na_2CO_3)—necessary to soften water the composition of which is known, may be calculated by the following equations, where C = lime (90 per cent.), and D = Na_2CO_3 (95 per cent.).

$$C = 1.12Fe + 3.46Al + 2.56Mg + 30.96H + 0.51HCO_3 + 1.42CO_2$$

$$D = 2.0Fe + 6.18Al + 2.78Ca + 4.58Mg + 55.41H - 1.86CO_3 - 0.92HCO_3$$

In the foregoing the symbols represent parts per million.

The injurious effects of the carbonates and sulphates of calcium and magnesium respectively are perhaps limited to those resulting from their low heat conducting power.

The tendency of magnesium chloride to decompose and liberate hydrochloric acid makes it especially objectionable because of its corrosive action. Unfortunately there is a lack of unanimity in the opinions regarding the action of this salt when (in solution) it is heated. This difference of opinion has resulted because most of the investigations on which these opinions are based were made on solutions containing magnesium chloride alone, while in other investigations this salt was associated in the solutions tested with other salts.

It seems to be well established that the tendency to decompose under the influence of dilution and heat is lessened by the presence of alkaline chlorides. For example Rideal[1] says: "This decomposition is retarded in the presence of alkaline chlorides, like common salt, so that sea water, although it contains a large percentage of magnesium chloride, may be evaporated nearly to dryness without the evolution of any hydrochloric acid, and even at the high temperature of boilers the decomposition is limited."

In striking contrast to this statement of Rideal is that of other authorities that dilution alone leads to the hydrolysis of magnesium chloride and the liberation of hydrochloric acid in accordance with the following reaction:

$$MgCl_2 + H_2O = MgO + 2HCl$$

Priming is the result either of the use of feed water containing a large percentage of dissolved or suspended matter, or of the concentration of such suspended or dissolved material in the boiler itself as a result of too infrequently blowing it down. Priming may also result from a sudden increase in the amount of steam generated—that is, in the rate of generation. When priming results from the use of water containing much dissolved matter, the obvious remedy is the selection of another source of supply if practicable. Otherwise, the trouble must be met by frequently blowing down the boilers. Of course, in plants where condensers are used, the trouble from priming is solved as the amount of raw feed water is small.

It is obviously very difficult to establish any standard for the classification of waters as "good," "fair" and "poor," which could be applied with equal justification to waters of all sections, for it is a matter of relative rather than of absolute values; that is, the classification of waters for any particular locality should be based rather on what might be considered the average quality of water there rather than on that of some other section. Therefore a water should be so classified as to show its quality relative to the best water procurable in the place in which it is to be used. Bearing this in mind, such a classification as is made in the table proposed by the American Railway and Maintenance of Way Association may be helpful.

CORRODING AND INCRUSTING CONSTITUENTS

Parts per Million	Classification
Not more than 90	Good
Not more than 200	Fair
Not more than 430	Poor
Not more than 680	Bad
More than 680	Very bad

A second table gives similar data for foaming constituents as follows:

FOAMING CONSTITUENTS

Parts per Million	Classification
Not more than 70	Very good
Not more than 150	Good
Not more than 250	Fair
Not more than 400	Bad
More than 400	Very bad

In all properly conducted power plants systematic testing of the boiler-feed water is and should be done.

Kennicott Cycloid Weir Meter

A new form of weir meter to indicate and record the flow of water has just been perfected by the Kennicott Co., of Chicago Heights, Ill. The weir itself is in the form of a right cycloid, and the flow through it is directly in proportion to the head above the crest of the weir. In other forms of weirs the flow is proportional to some odd power of the head, and to obtain a reading directly proportional to the head complicated mechanisms are necessary to eliminate the radical sign. As the cycloid weir already possesses the desirable features of a flow in direct proportion to the head, the complicated mechanism just mentioned may be eliminated and the connection between the weir and the meter be of simple character. The meter is equally accurate at high or low heads. As the water falls vertically downward from the edge of the weir, there is no inaccuracy at low flow due to the water trickling and drizzling down the wall of the weir body.

[1] S. Rideal, "Water and Its Purification," p. 224

Fig. 1 is a phantom view showing the meter complete with storage and weir chambers and the indicating and recording devices. The weir itself is made of cast brass. It is hollow, the water flowing around it through a slotted orifice down through the weir into the storage compartment. According to the capacity required, from one to four weirs are used, each having a capacity of 150,000 lb. per hour. The weir box, which is constructed of ⅜-in. steel plate, is separated into two compartments—the weir chamber above and the storage compartment below—by the weir bedplate. Onto this bedplate are bolted the desired number of weirs.

Water enters the weir chamber through a balanced valve which is governed by a float in the storage chamber. Upon entering, the water encounters a circular baffle around the pipe and in the channel of approach straight perpendicular baffles which serve to still the water before it reaches the weir.

The meter has a continuous register, a graphical recorder and an instantaneous indicator. The instrument last mentioned shows directly how much water is flowing through the weir at the particular moment of observation. The graphical recorder makes a continuous record of the readings, which appear on the indicator. It carries a tape good for a period of two months, but daily or weekly charts may be substituted. The continuous register, is a counter showing at all times the volume of water that has passed through the weir, Fig. 2.

As will be evident from the phantom view, the indicator and register are operated by a float in a special chamber connected to the weir compartment by a small pipe just below the crest of the weir. As the head of water in the weir compartment and likewise in the float chamber rises or falls, the float is actuated accordingly,

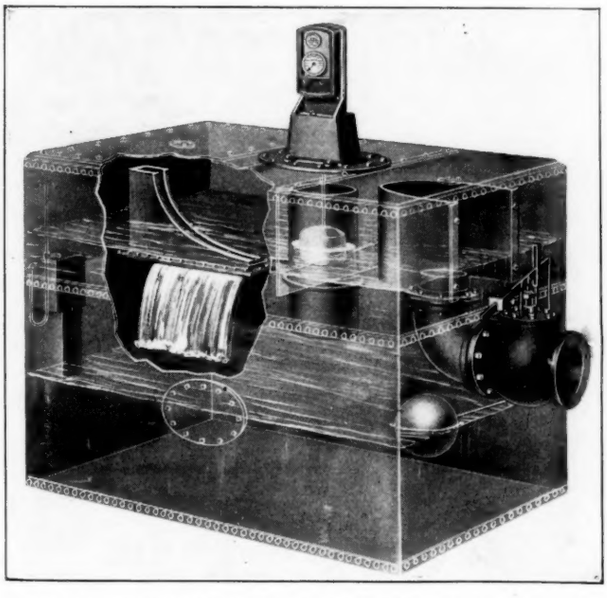


FIG. 1. PHANTOM VIEW OF CYCLOID WEIR METER

thus moving the vertical shaft carrying the small friction wheel and the circular rack shown in Fig. 3. The large friction plate appearing in the same illustration is driven by a double-spring eight-day clock mechanism and is rotated continuously when the weir is in operation. When there is no head on the weir, the small friction gear is in a neutral position at the center of the plate, so that no record is made. The pinion which carries the hand of the indicator and is turned by the circular rack is at its zero position.

As the water comes on the weir, the float rises, moving the pointer of the indicator to its proper position. It will be seen that as the friction wheel rises on the plate

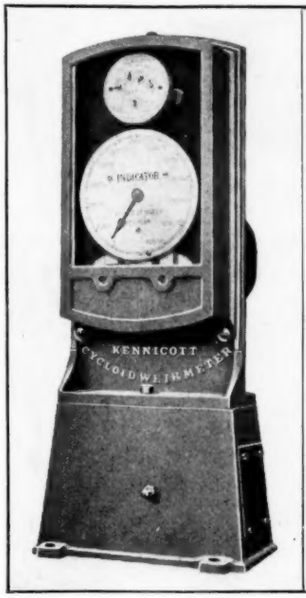


FIG. 2. INDICATOR AND REGISTER

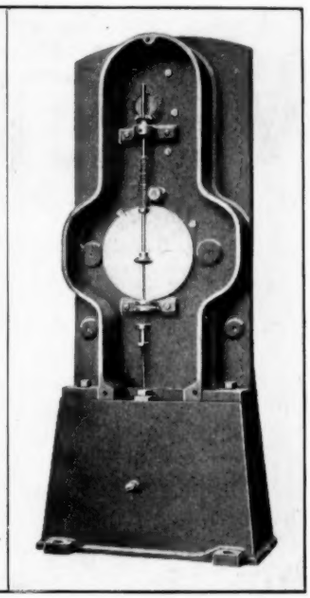


FIG. 3. OPERATING MECHANISM

the driving ratio changes, so that the higher the head the faster the vertical shaft will be revolved and likewise the register operated by the gears at the top. By this simple mechanism, therefore, the register is driven in proportion to the head of water above the weir, and as the flow of water through the cycloidal weir is in direct proportion to this head, the quantity of water that has passed through the weir is given by the register without the use of corrective mechanism. The meter is guaranteed accurate within 1½ per cent., and actual tests made show that the results obtained by its use are even more accurate than when the weighing or measuring is done by hand.

Stretch or Increase in Diameter Due to Pressure in 4-in. malleable tees tested to destruction was found to be from ⅛ to ¼ in. before failure, measured with calipers, causing them to become loose on the pipe thread and leak. The bodies were ¼ in. thick, and the bursting pressure was approximately 2,900 lb. per sq.in. Pinholes developed from 1,000 (none below) to 2,500 lb. Galvanizing improved this feature, the tees sustaining a higher pressure in every case before leakage. Final failure occurred at approximately the same pressure whether they were galvanized or black.

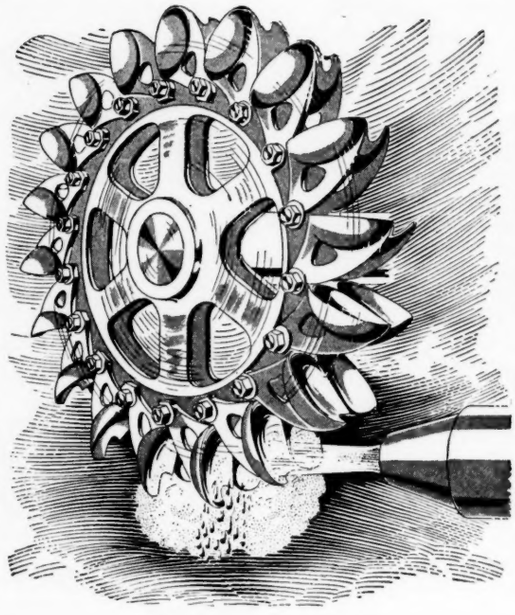
Effect of Pipe Curvature on the Flow of Water—An extensive series of experiments at Detroit by Williams, Hubbell and Fenkell (Trans. A. S. C. E., 1902), they claim "prove beyond question or doubt that the hitherto accepted notions of the laws governing curve resistance are wholly in error. The resistance due to curvature is proved to be very much less in the short- than in the long-radius curves for the same total length of pipe and angle of deflection." The 90-deg. curve introducing the least resistance in a total length of 80 diameters they found to be one formed to a radius of between 2 and 2½ diameters as determined with 30-in. and 12-in. pipes in service. In a 90-deg. bend on a 6-ft. radius, the loss of head was found to be 15.7 per cent. greater than an equal length of straight pipe, with a 10-ft. radius 17.3 per cent., with a 25-ft. radius 52.7 per cent., and with a 60-ft. radius 90.2 per cent. greater than an equal length of straight pipe.

Force, Velocity and Energy in Jets of Water and Steam

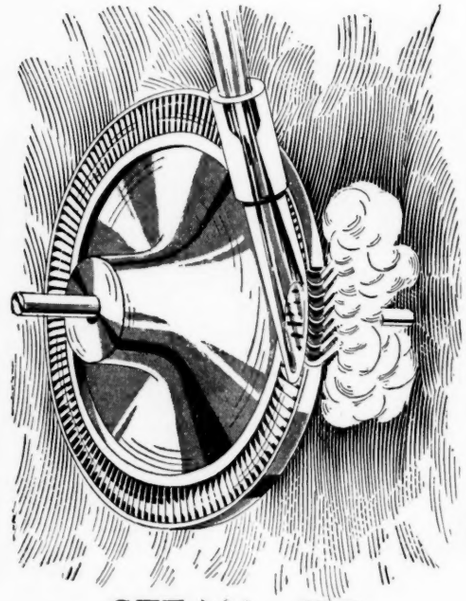
A jet of steam and a jet of water of the same diameter issue under the same pressure. Which will hit the harder, and which will be capable of doing the more work?

It is difficult to conceive how a jet composed of so imponderable a substance as highly expanded steam can produce so much power as it does upon the blades of a steam turbine. The potency of moving water one can readily appreciate. It has some mass to it. The effect of a stream from a fire hose is manifest, visible and vigorous; but when it comes to propelling a wheel by a moving gas or vapor, one is apt to think of the weakling windmill and shake his head.

The secret is in velocity. The high velocity acquired by the expanding steam brings about the delivery of a considerable weight even of the low-density material per unit of time, and as the energy in a given weight increases as the square of its velocity, the impacting or reacting force and power-producing possibilities of a jet of even this impalpable vapor is quite surprising, the horsepower of the steam jet being over 25 times that of the water.



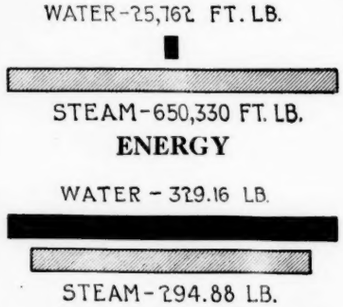
WATER JET

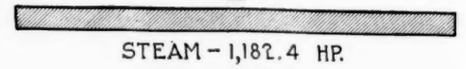


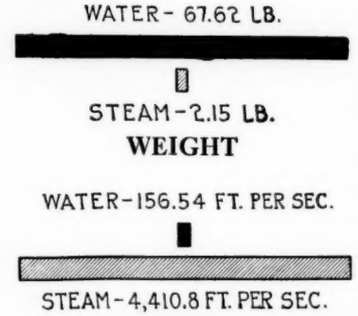
STEAM JET

Imagine a jet of water issuing under a head equivalent to 165 lb. and a jet of steam expanding from 165 lb. superheated 150 degrees to 29-in. vacuum, each jet having a cross-section of 1 sq.in. at its smallest section. The steam jet would discharge only 2.15 lb. per sec., while the water jet would discharge 67.62 lb., over 30 times the weight delivered by the steam jet in the same time. But the steam would be going at over 4,400 ft. per sec., while the water would be moving with a velocity of only 156.54 ft. per sec., or not one twenty-eighth as fast. The steam would press upon the blades of a wheel so designed as to extract all of its energy and bring it to rest with a force of 294.88 lb., the water with a force of 329.16 lb.; but the steam turbine would run so much faster and exert its slightly smaller force through so much greater a space in the same time that the steam jet would do 1,182.4 hp. against the water's 46.8.

If the steam jet were of the same size as the water jet outside of the nozzle the figures would be: Weight 0.058 lb. per sec., impact 8 lb., energy 17,624 ft. lb. per sec., hp. 32.

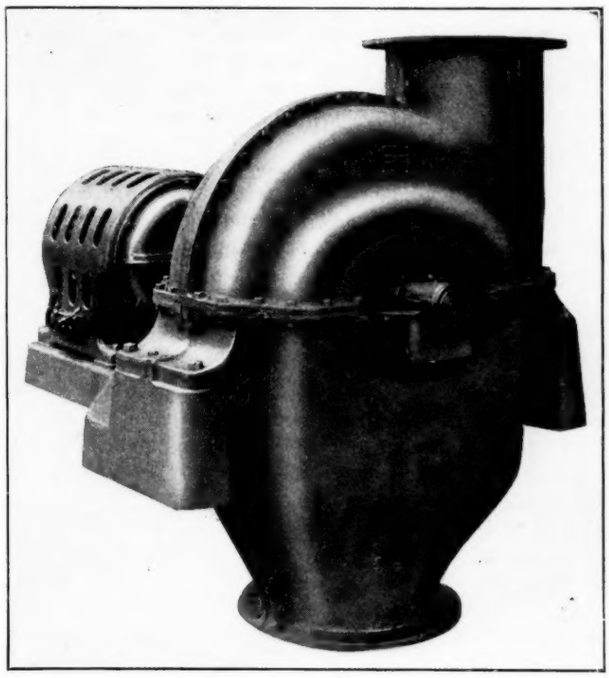






Low-Pressure Turbo-Blower

The Ingersoll-Rand Co., New York City, has brought out a low-pressure turbo-blower to handle volumes from



LOW-PRESSURE TURBO-BLOWER

3,000 to 35,000 cu.ft. per min. at from 1 to 2½ lb. This machine is adapted to such service as foundry cupola blowing, atomizing oil for oil burners, supplying blast to heating and annealing furnaces of various kinds, blowing air for water-gas generators, pneumatic conveying and ventilating systems of the various types.

The turbo-blowers are of the single-stage double-flow type and are furnished for electric-motor, steam-turbine or waterwheel drive. Electric drive is generally employed for the classes of service mentioned, the high operative speed permitting direct coupling to the motor.

The turbo-blower maintains constant pressure while delivering any volume from zero to maximum demand and proportionately varying the electrical horsepower input.

Convenient Wiring Table

By George Wright

The accompanying table makes a convenient reference for determining the proper size of wire for carrying a given number of amperes at a predetermined drop. It was figured in accordance with the 1913 code and is intended for direct current only. The area in circular mils was determined by the formula following:

$$Circ.\ mils = \frac{Amperes \times distance\ one\ way \times 21.2}{volts\ loss}$$

To use the table it is first necessary to multiply the amperes to be delivered by the distance in feet one way. This gives the ampere-feet incorporated in the body of the table. Find this product in the column headed by whatever voltage loss has been decided upon, then follow horizontally to the left for the proper size of wire. If the exact value of the product is not given in the table, the next larger value is taken, so that the size of the wire will be somewhat larger than necessary and consequently the drop a little less than that previously selected.

Suppose, for example, that it is desired to transmit 150 amp. a distance of 200 ft. with a drop of 4 volts. Then

$$150 \times 200 = 30{,}000\ amp.\text{-}ft.$$

In the 4-volt drop column the nearest figure to 30,000 is 31,860, which corresponds to No. 000 wire.

WIRING TABLE FOR DIRECT CURRENT

Size Wire B. & S. Gage	Area, Circular Mils	Allowable Amperes Rubber Insulation	Allowable Amperes Other Insulation	Capacity in Ampere-Feet with the Following Volts Loss 1	2	3	4	5	6	7	8	9	10
18	1,624	3	5	76	152	228	304	380	456	532	608	684	760
16	2,583	6	10	121	242	363	484	605	726	847	968	1,099	1,210
14	4,107	15	20	193	386	579	772	965	1,038	1,351	1,544	1,787	1,930
12	6,530	20	25	308	616	924	1,232	1,540	1,848	2,156	2,464	2,772	3,080
10	10,380	25	30	490	980	1,470	1,960	2,450	2,940	3,430	3,920	4,410	4,900
9	13,090	Not used	Not used	617	1,234	1,851	2,468	3,085	3,702	4,312	4,936	5,553	6,170
8	16,510	35	50	780	1,560	2,340	3,120	3,900	4,680	5,460	6,240	7,020	7,800
7	20,820	Not used	Not used	982	1,964	2,946	3,928	4,610	5,892	6,874	7,856	8,838	9,820
6	26,250	50	70	1,235	2,470	3,705	4,940	6,175	7,410	8,645	9,880	11,115	12,350
5	33,100	55	80	1,560	3,120	4,680	6,240	7,800	9,360	10,920	12,480	14,040	15,600
4	41,740	70	90	1,969	3,938	5,907	7,876	9,845	11,814	13,783	15,752	17,721	19,690
3	52,630	80	100	2,482	4,964	7,446	9,928	12,410	14,892	17,374	19,856	22,338	24,820
2	66,370	90	125	3,130	6,260	9,390	12,520	15,650	18,780	21,910	25,040	28,170	31,300
1	83,690	100	150	3,999	7,998	11,997	15,996	19,995	23,994	27,993	31,992	35,991	39,990
0	105,500	125	200	4,976	9,942	14,928	19,884	24,880	29,856	34,832	39,768	44,784	49,760
00	133,100	150	225	6,278	12,556	18,834	25,112	31,390	37,668	43,946	50,224	56,502	62,780
000	167,800	175	275	7,915	15,930	23,745	31,860	39,575	47,490	54,405	63,720	71,235	79,150
0000	211,600	225	325	9,981	19,962	29,943	39,924	49,905	59,886	69,867	79,848	89,829	99,810
....	200,000	200	300	9,433	18,866	28,299	37,732	47,165	56,598	66,031	75,464	84,897	94,330
....	250,000	235	350	11,790	23,580	35,370	47,160	58,950	70,740	82,530	94,320	106,110	117,900
....	300,000	275	400	14,150	28,300	42,450	56,600	70,750	84,900	99,050	113,200	127,350	141,500
....	350,000	300	450	16,500	33,000	49,500	66,000	82,500	99,000	115,500	132,000	148,500	165,000
....	400,000	325	500	18,866	37,732	56,598	75,464	94,330	113,196	132,062	150,928	169,794	188,660
....	450,000	360	545	21,273	42,546	63,819	85,092	116,365	127,638	148,911	170,184	181,457	212,730
....	500,000	400	600	23,580	47,160	71,740	94,320	117,900	143,480	165,060	188,640	212,220	235,800
....	550,000	420	635	25,943	51,886	77,829	103,772	129,715	155,658	181,601	207,544	233,487	259,430
....	600,000	450	680	28,300	56,600	84,900	113,200	141,500	169,800	198,100	226,400	254,700	283,000
....	650,000	475	720	30,660	61,320	91,980	122,640	153,300	183,960	214,620	245,280	275,940	306,600
....	700,000	500	760	33,000	66,000	99,000	132,000	165,000	198,000	231,000	264,000	297,000	330,000
....	750,000	525	800	35,376	70,752	106,128	141,504	176,880	212,256	247,632	283,008	318,384	353,760
....	800,000	550	840	37,732	75,464	113,196	150,928	188,660	226,392	264,124	301,856	339,588	377,320
....	850,000	575	880	40,000	80,000	120,000	160,000	200,000	240,000	280,000	320,000	360,000	400,000
....	900,000	600	920	42,546	85,092	127,638	170,184	212,730	255,276	297,822	340,368	382,914	425,460
....	950,000	625	960	44,811	89,622	134,433	179,244	224,055	268,866	313,677	358,488	403,299	448,110
....	1,000,000	650	1,000	47,160	94,320	141,480	188,640	235,800	282,960	330,120	377,280	424,440	471,600

Power-Plant Tolerance—W. W. Lackie, in his presidential address to the Institution of Engineers and Shipbuilders in Scotland, mentioned that the British Electric and Allied Manufacturers' Association introduces in its latest publication the term "tolerance" as representing the permissible amount of deviation in observed results from guaranteed results in connection with new plants. In steam consumption this association has fixed on a 2½-per cent. tolerance to be allowed before any penalty is exacted or bonus allowed.

Foreign Gases in Refrigeration*

By H. J. Macintire†

SYNOPSIS—The author explains, by the help of Dalton's law of gases, how foreign gases in refrigeration plants affect the pressure. He contends that according to the law of diffusion (chemistry) there is no definite separation of the gases and the ammonia vapor, and that ammonia is always blown out when purging, even before the crackling noise occurs.

Considerable attention from refrigerating engineers is now being directed toward the impurities in the refrigerant, the causes, the nature, and the effect of foreign gases. Whereas with the usual designs of ammonia compressors a part at least of these gases may be atmospheric air drawn into the machine through the stuffing-boxes, which are subject at times to a partial vacuum, yet it does not seem even remotely probable that all such gases are due to such causes.

Professor Plank[1] seems to think it probable that continued action in the refrigerating cycle, especially with the dry compression, where the temperature of discharge is frequently as high as 200 to 300 deg. F., tends to break the chemical bond between the hydrogen and nitrogen. He also thinks that rapid compression promotes the same action, but is doubtful if we ever attain piston speed sufficiently great for this purpose. However, that some decomposition takes place is positive, although the cause—whether electrolytic, dynamic or chemical—is not clear at present.

To explain the effect of air or of foreign gases in the refrigerating cycle, and more particularly in the condenser where it collects, one should consider the laws of partial pressures. Suppose a condenser contains pure saturated ammonia. The pressure given by the gage connected to the condenser is that which corresponds to the temperature at which the ammonia is being condensed, and this pressure may be found from the ammonia tables. When air or inert gases get into the system this is no longer true, but the gage will show a pressure higher than that given in the tables.

Calculating Pressure of Air and Gas

As an example, suppose that a condenser contained pure saturated ammonia at 70 deg. F. The pressure corresponding is about 114.5 lb. per sq.in., and the volume of 1 lb. is 2.3 cu.ft. Suppose now that an inert gas (air, for purposes of illustration) collects in the condenser and, not being able to get out on account of the liquid seal in the liquid receiver, finally becomes concentrated until, let us say, equal weights of air and ammonia are present. The temperature of the air will be the same as that of the ammonia, and the pressure[2] exerted by it will be

$$144p_1 \times 2.3 = 1 \times 53.4 \times (70 + 460)$$

$$p_1 = \frac{53.4 \times 530}{144 \times 2.3} = 85.3 \text{ lb. per sq.in. abs.}$$

and the total pressure in the condenser (and of course against which the compressor has to work) will be

$p = p_1 + p_2 = 85.3 + 114.5 = 199.8$, *or* 185.1 *lb. gage.*

In regard to the means of purging, as is seen to be inevitable from the foregoing, we must not expect that if the two gases are present in the same tank or pipe, they will remain separate, like oil and water. Such a condition is impossible, although it seems probable. Frequently in purging there does seem to be a time when inert gases abruptly cease and the ammonia begins to issue forth. However, the law of diffusion in chemistry states that all gases tend to become uniformly diffused and that the rate of this intermingling is inversely as the square root of the vapor density. Hydrogen, then, will diffuse about four times as fast as oxygen, or ammonia, but nitrogen only slightly faster than ammonia. Such being the case, it does not seem reasonable to suppose that air, which is heavier than ammonia, or the decomposed parts of ammonia (hydrogen and nitrogen) will collect in the header placed sometimes at the top of a stand of condenser pipes for that purpose. Let us, however, consider carefully a typical case—say that of an atmospheric condenser.

Assume that the condenser has a mixture of air and ammonia vapor. The compressor is shut off and water is allowed to continue running over the pipes. As no more gas comes into the condenser, the water has little duty to perform and the mean temperature becomes colder in the condenser, first at the top and then one by one in each pipe until the whole stand is at about the temperature of the entering water. Along with the lowering of temperature there is some condensation of ammonia, and thereby (as the inert gases are not condensable) the mixture becomes less rich in percentage of ammonia. A drop of pressure would also occur, due to less ammonia tension and less partial pressure of air with lower temperature. Supposing that the condenser had one-third as much, by weight, of air as ammonia and a mean temperature of 80 deg. F., and that during the process mentioned the temperature fell to 60 deg., then the pressure and relative volumes would become

$$p_1 = \tfrac{1}{3} \times \frac{53.4 \times (80 + 460)}{144 \times 1.94} = 34.4 \text{ lb. per sq.in.}$$

$$p_2 = p_{80} \text{ deg. F.} = 153.9 \text{ lb. per sq.in.}$$

$$p = p_1 + p_2 = 34.4 + 153.9 = 188.3 \text{ lb.}$$

The volume of one pound of ammonia at 80 deg. is 1.94 cu.ft., and at 60 deg. it is 2.73, so there has been a condensation of 32.6 deg. and the relative weights are about 0.33 lb. of air and 0.66 lb. of ammonia as compared with 0.33 and 1.0 before. The new pressure is

$$p = p_2 + p_1 = 107.7 + 33.2 = 140.9 \text{ lb.,}$$

or 126.2 *lb. gage.*

Relative to purging, when at first only air seems to escape through the purge valve into the bucket of water

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*Other articles on this subject recently published in "Power" are: "Decomposition of Ammonia and the Chances of Explosions," by F. L. Fairbanks, Nov. 23, 1915; "Foreign Gases and Solids in the Absorption Plant," by H. G. Gibson, Dec. 28, 1915; "Decomposition of Ammonia," by Prof. R. Plank, Dec. 28, 1915.

†Consulting engineer, Seattle, Wash.

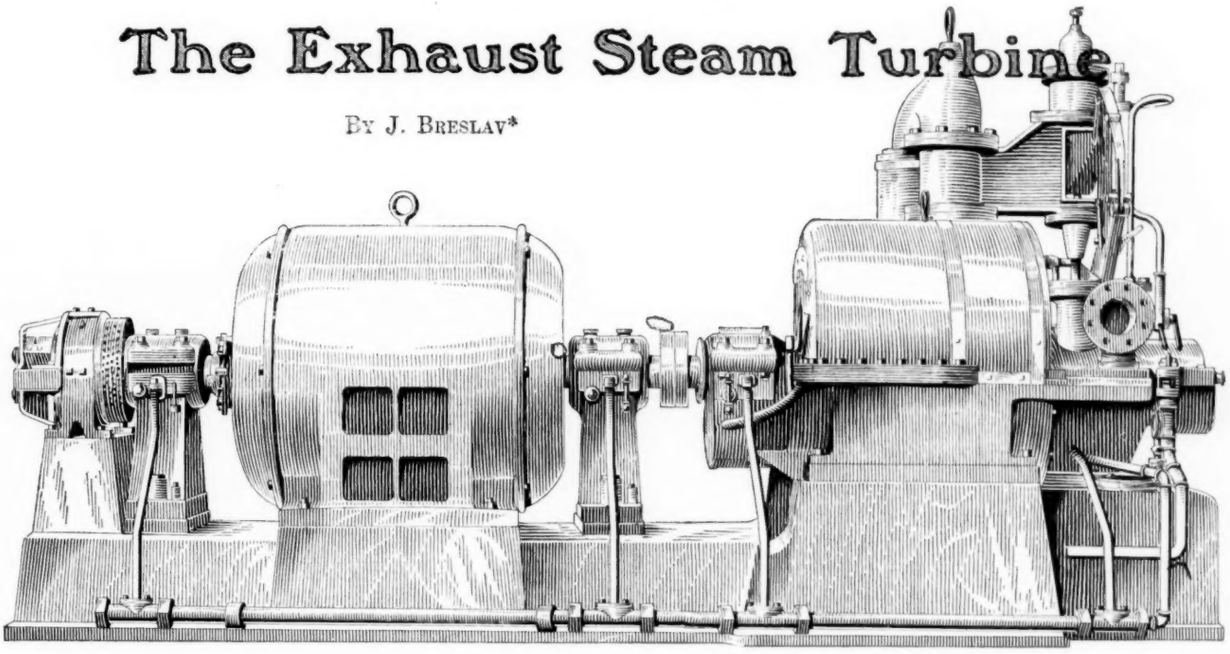
[1]"Zeit. fur die Gesamte Kalte-Industrie," 1915; "Power," Dec. 28, 1915.

[2]Dalton's law of partial pressures states that in mixtures of gases having no chemical action with each other, the total pressure is the sum of the pressures of each gas when occupying the space alone.

and suddenly the peculiar cracking noise is noticed which is taken as the indicator of the removal of the inert gases, I believe that ammonia always comes out of the purge valve. At first the stuff escaping to the bucket is rich in air or foreign gases. The ammonia present is protected by these gases, and absorption by the water progresses slowly and consequently without appreciable noise. That some absorption takes place is clear, as the bubbles diminish in size as they ascend. As the purging progresses, the mixture becomes stronger by the evaporation of some liquid ammonia left in the pipes, and the ammonia in the mixture has a chance to make itself evident. That the foregoing reasoning is substantiated by fact may be seen in that frequent recharging is necessary where much purging has to be employed and because the ammonia smell is always evident.

The Exhaust Steam Turbine

By J. Breslav*



SYNOPSIS—Discusses the merits of low- and mixed-pressure turbines for existing plants requiring more power.

Before the increase to pressures as high as 200 lb., superheating claimed attention as a means of increasing plant economy. As with high pressures, engine and plant construction limit the superheat that can be used to from 125 to 200 deg. F., depending on the pressure; and as the gain due to superheat is about 10 per cent. for each 100 deg., the improvement in an existing plant rarely exceeds 15 per cent., but considerable energy is to be had by expanding the exhaust steam in a low-pressure turbine.

Before it was fully realized what gains could be procured through the use of high vacuum, most attention was paid to the conditions under which steam was generated. When one hears it said for the first time that there is no more energy in steam expanding from a certain pressure above down to atmospheric pressure than there is in expanding below atmospheric pressure, he is surprised. Fig. 1 shows the vacuum required in order that as much work shall be obtained from the steam in expanding below the atmosphere as from expanding from higher pressure to the atmosphere. From this curve it will be noticed that there is as much energy in steam expanding from 0 to 26 in. vacuum as from 75 lb. to 0 gage, and that an increase to 28 in. is equivalent to an increase to 125 lb. gage, the increase of 2 in. of vacuum being equivalent to raising the pressure 50 lb.

*With the Terry Steam Turbine Co., Hartford, Conn.

Previous to the advent of the steam turbine the highest economical vacuum was about 26 in. The turbine's ability to take care of large volumes of steam and to avoid initial or cylinder condensation makes a vacuum of 29 in. desirable for economical reasons. Fig. 2 shows

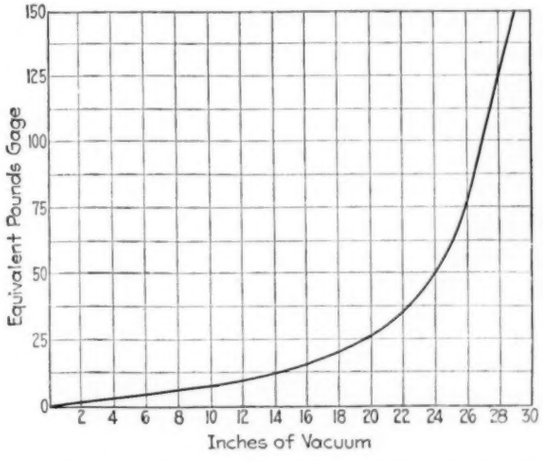


FIG. 1. HOW EXPANSION OF STEAM IN A VACUUM COMPARES WITH EXPANSION ABOVE VACUUM

the theoretical percentage increase in power available per added inch of vacuum. From this one observes that an increase from 26 to 27 in. on a high-pressure condensing turbine designed for 150 lb. pressure increases the horsepower 5 per cent., that an increase from 27 to 28 in. increases the horsepower 6 per cent., from 28 to

29 in., 10 per cent., making an increase in horsepower from 26 to 29 in. of 22.5 per cent., or a corresponding decrease in steam consumption for the same horsepower. In short, the steam turbine effects a great reduction in steam consumption irrespective of initial pressure conditions.

The gains possible by taking advantage of high vacuum have brought about the exhaust-steam turbine. Since

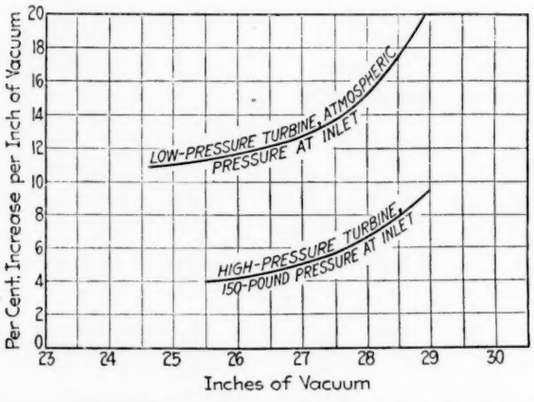


FIG. 2. INCREASE IN CAPACITY PER INCH OF VACUUM

the noteworthy installation at the plant of the Interborough Rapid Transit Co., exhaust-steam or low-pressure turbines have been installed in many plants—in some to fulfill expectations, in others to be an expense. Their proper application requires careful study of many conditions and a thorough knowledge of the types of turbines, the methods of application possible and the local conditions.

The preliminary study requires obtaining, first, the pressure at which the turbine will receive exhaust steam; second, the most economical vacuum obtainable at the plant; third, the quantity, and if possible, the quality of the exhaust steam; fourth, the variation in supply of exhaust steam; fifth, the relation between the purpose of the source of exhaust steam and the proposed turbine.

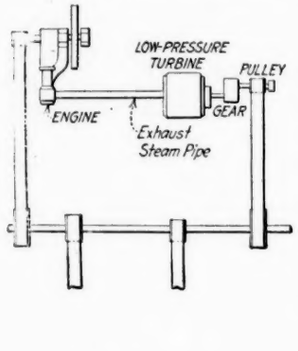


Fig. 3

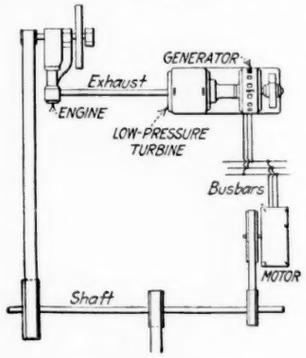


Fig. 4

FIGS. 3 AND 4. DRIVING CONNECTIONS FOR LOW-PRESSURE TURBINES

The most economical vacuum depends on the temperature, quantity and cost of cooling water available, as under exceptional circumstances the advantage of the high vacuum might be destroyed by the expense of operating and installing condensers.

As is true with high-pressure turbines, the economy is affected by the amount of moisture or superheat in the steam. For that reason and also because all turbine builders base their guarantees on dry steam at the turbine throttle, when figuring on the quantity of exhaust steam available, it is necessary to deduct approximately 2 per cent. in total steam for each 1 per cent. of moisture in the exhaust steam. For certainty it is best to assume that only 90 per cent. of the steam consumed by the engine will be available for work in the low-pressure turbine.

Upon the variation in the supply of the exhaust steam and the relation between the purpose of the source of exhaust steam and the purpose of the proposed turbine depends the choice of type of installation.

The exhaust-steam turbine may be divided into three branches, the method of division depending on the supply of low-pressure steam. These are: Straight low-pressure, mixed-pressure and high-and-low-pressure turbines.

Low-pressure turbines use exhaust steam only and are installed where there is an ample supply of low-pressure steam to carry the load at all times. Mixed-pressure turbines carry the load (1) on low-pressure steam alone, (2) on high-pressure steam alone, or (3) on both high- and low-pressure steam at the same time. High-and-low-pressure turbines can carry the load either on high-pressure steam or on low-pressure steam, but are not arranged to carry the load on both high- and

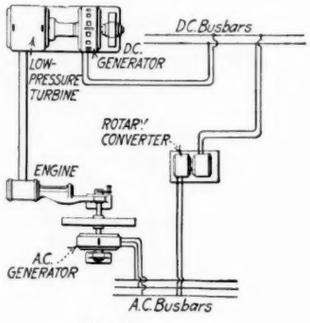


Fig. 5

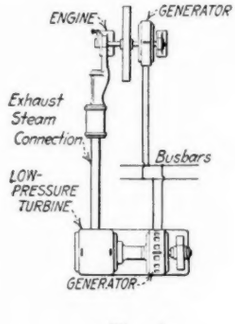


Fig. 6

FIGS. 5 AND 6. ENGINE GENERATORS AND TURBINE GENERATORS OPERATING IN PARALLEL

low-pressure steam at the same time. These are still further divided, depending on how they are installed, according to, first, the compound system under which the turbine receives steam from a number of engines all of which exhaust into a common main or receiver and, second, the individual system where the turbine gets its steam from one engine. The first system is used when there are a number of engines operating noncondensing, the exhaust from no one of which would be sufficient to carry the required load on the low-pressure turbine. This system would be used in connection with noncondensing generator sets, hoisting engines, mill engines and drop forges. The turbine may be used to drive generators, drive shafting through bearing or gears, drive machines direct or through gears, and to drive pumps and other rotary apparatus.

In these applications wherever possible it is advisable to install the turbine according to the independent system, as the governor on the low-pressure turbine may be done away with at a saving in first cost and a more advantageous use of the exhaust steam because, as will be explained later, a balance can be maintained between the steam furnished the high-pressure engine and the low-pressure turbine.

The application of the low-pressure turbine without a governor is made under the following conditions:

(1) Where the turbine is to be connected directly to the same lineshafting as the engine, either through a belt or through a synchronous motor, as in Figs. 3 and 4; (2) when the generator driven by the turbine is to operate in parallel with the engine, being connected

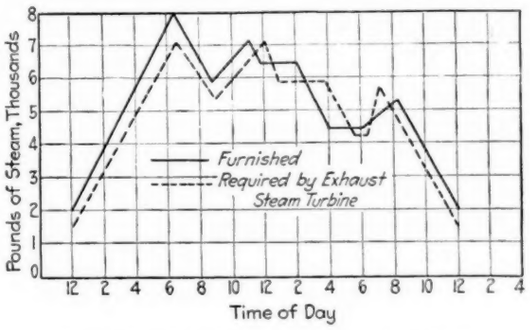


FIG. 7. LOW-PRESSURE TURBINE SUITABLE WHEN STEAM AVAILABLE IS LIKE THIS CHART SHOWS

either to the same busbars or through a rotary converter, as in Figs. 5 and 6.

Under these conditions regulation is done by the engine governor. With the use of direct belt connection and also when they are connected through a belted synchronous motor, the engine and turbine will start up practically simultaneously. As the steam passes through the engine into the turbine, the latter will tend to take as much load as possible. Having no governor, it will tend to speed up. This will speed the shafting and through this the engine. As the engine tends to rise in speed, the engine governor will close, decreasing the steam to the engine and hence to the turbine also. This action will continue until a proper balance is established, the turbine taking as much load as possible.

The action is practically the same when the engine and turbine drive generators operating in parallel. With a direct-current generator, if because there is no governor the generator speed tends to increase, the voltage will rise accordingly, so that the generator will take more load until it reaches its operating speed. Taking the load from the engine will raise its speed so that the engine governor will close, decreasing the supply of steam. With an alternator the low-pressure turbine will take as much load as it can, depending on the amount of low-pressure steam furnished. If it takes a large proportion of the load, the engine will take little, so that its governor will be open only an amount necessary to carry the load on both machines.

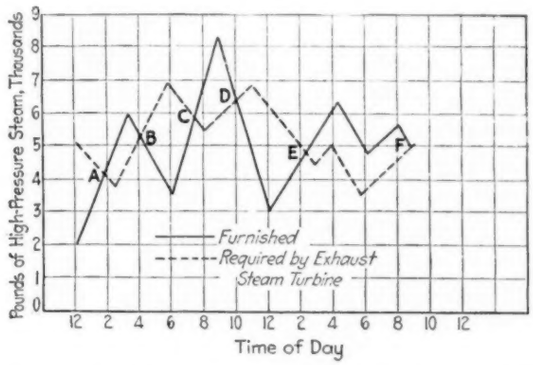


FIG. 8. STEAM SUPPLY FAVORS MIXED PRESSURE TURBINE

Where the engine is used for driving lineshafting and the low-pressure turbine drives a generator furnishing current for lights or individual motor drive so that there is no relation between the use of the engine and the turbine, a speed-regulating governor must be used on the turbine. The necessity for this governor is evident from Figs. 7 and 8. If the load conditions are as shown on these curves, it is wise to have a relief valve in the line between the engine and the turbine so that an excessive back pressure will not be put on the engine when it furnishes more steam than the turbine requires. From a casual glance at these curves it would seem that a mixed-pressure turbine would be required in both cases, as at certain periods there is less steam supplied by the engine than is required to carry the load. Additional steam must be supplied in some way from the boilers. In a strictly low-pressure turbine it is not possible to use the steam direct from the boilers, so that either a reducing valve must be used or a high-pressure element must be supplied with the turbine at its installation. During its time of operation the reducing valve is the less economical because no advantage is taken of the drop in pressure.

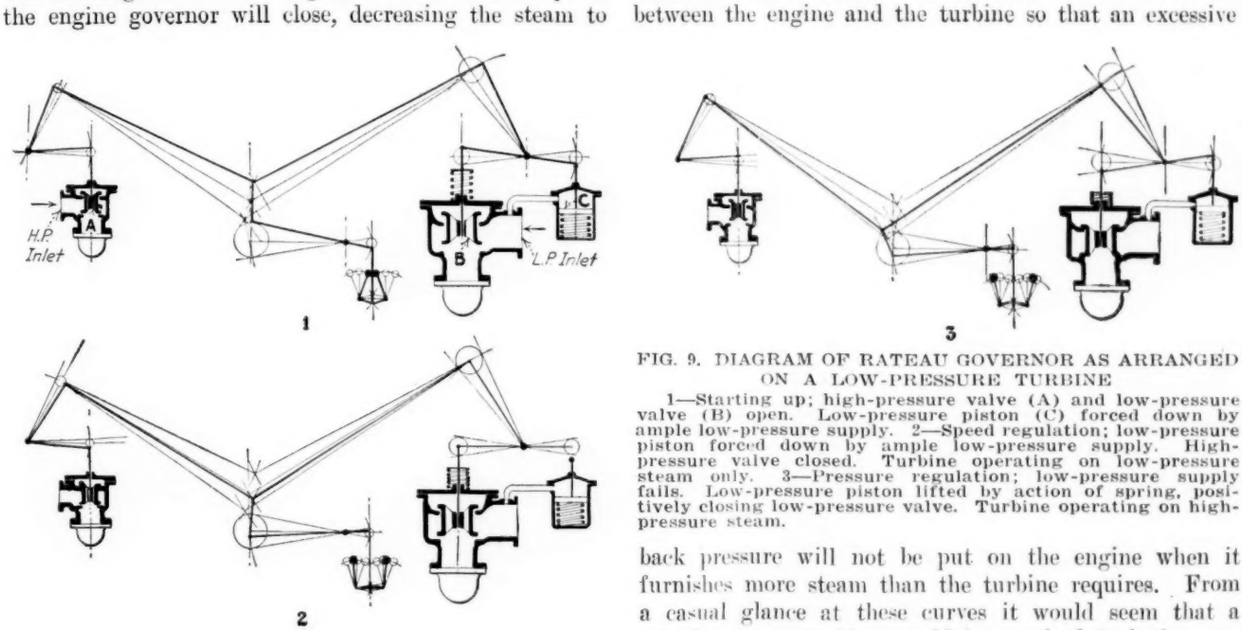


FIG. 9. DIAGRAM OF RATEAU GOVERNOR AS ARRANGED ON A LOW-PRESSURE TURBINE

1—Starting up; high-pressure valve (A) and low-pressure valve (B) open. Low-pressure piston (C) forced down by ample low-pressure supply. 2—Speed regulation; low-pressure piston forced down by ample low-pressure supply. High-pressure valve closed. Turbine operating on low-pressure steam only. 3—Pressure regulation; low-pressure supply fails. Low-pressure piston lifted by action of spring, positively closing low-pressure valve. Turbine operating on high-pressure steam.

With load distribution as shown in Fig. 7, where the lack of low-pressure steam comes for only a short period during the day, the straight low-pressure turbine with reducing valve would usually prove the most economical, whereas with load distribution as in Fig. 8, the mixed-pressure turbine would be advisable.

Besides being differentiated by being installed under the independent or compound system, the mixed-pressure turbine may further be divided into two classes—that in which the high- as well as low-pressure governor valve is used, and that in which the low-pressure governor is omitted.

The former of these is capable of fulfilling all points of definition as given and is equipped with a special governing mechanism arranged to take care of the varying supply of low-pressure steam and admit the high-pressure steam as it is required. Referring back to Fig. 8, the low-pressure valve would control from points *A* to *B*, *C* to *D* and *E* to *F*, where there was always sufficient low-pressure steam to carry the load. At these points the high-pressure valve would be closed, whereas between these intervals, or where the supply of low-pressure steam would not be sufficient to carry the load, the high-pressure valve would open, admitting only sufficient high-pressure steam to help carry the load. When no low-pressure steam was being supplied, as from *F* on, the low-pressure valve would be closed and the turbine would be carrying its load strictly on high-pressure steam. This action requires a special governor mechanism, a diagrammatic arrangement[1] of which, with an explanation, is shown in Fig. 9.

Turbine Should Have Vacuum Breaker

The second type of mixed-pressure turbine is capable of carrying the load on high-pressure steam only or on a mixture of high- and low-pressure steam, but is not able to carry it on low-pressure steam alone. This type is arranged so that it has only one governor valve and governor mechanism. It is equipped with an inlet into

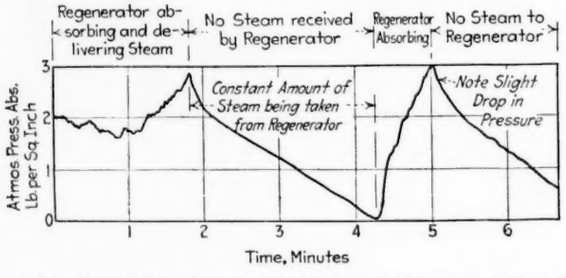

Regenerator absorbing and delivering Steam
No Steam received by Regenerator
Regenerator Absorbing
No Steam to Regenerator
Constant Amount of Steam being taken from Regenerator
Note Slight Drop in Pressure
Atmos Press. Abs. Lb. per Sq. Inch
Time, Minutes

FIG. 10. SHOWING HOW REGENERATOR ABSORBS AND GIVES UP HEAT

The regenerator was receiving steam at rates varying from 125,000 lb. to zero lb. per hr.

one of the low-pressure stages into which steam flows directly. The amount of steam that is likely to be furnished to this turbine should never be sufficient to carry the whole load on the turbine. Should this happen the high-pressure valve would close and there would be nothing to prevent the turbine from running away. Even though it is reasonably certain that this will never occur, this turbine should be equipped with a vacuum breaker or a speed-control emergency governor which would close the low-pressure inlet should there be a surplus of low-pressure steam.

[1]This governor is of the Rateau type and used on the Terry turbine.

With this turbine it is advisable to use a special type of valve known as a flow valve, the purpose of which is to prevent the vacuum from creeping back into the exhaust-steam line. At first it would not seem as though this would be an objectionable feature, as the back pressure on the source of supply would be lowered. The danger

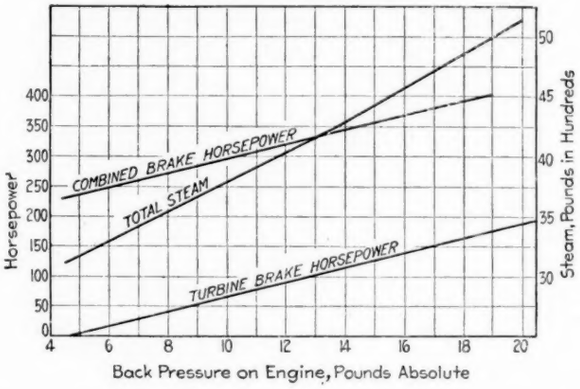


FIG. 11. SHOWING STEAM CONSUMPTION FOR INCREASED POWER FURNISHED BY LOW-PRESSURE TURBINE

of such a condition however, lies in the difficulty in keeping the large low-pressure mains tight, and the possibility of poor valve action of the engine due to improper setting for vacuum. In plants where there is only a small length of piping between the engine and the turbine this flow valve is not vitally necessary to successful operation.

There is one type of plant in which the supply of low-pressure steam varies independently from the demand of the exhaust-steam turbine, which does not necessarily require the use of a mixed-pressure turbine and for which the use of such a turbine might prove poor economy. Into this class fall plants consisting of hoisting engines, rolling-mill engines, steam hammers and forges, where the load might be said to be intermittent rather than varying. With this type of plant a regenerator is used. This receiver, or regenerator, possesses the ability to store up the heat from the steam when the engine supplies more than the turbine requires and to give up this heat and generate steam when the supply from the engine fails, in this manner maintaining the flow of steam to the turbine at a constant rate. The curve, Fig. 10, shows the action of the regenerator. The regenerator may be used to advantage with a mixed-pressure turbine only if the supply of exhaust steam from the regenerator varies over periods greater than five or ten minutes. Up to this length of time the regenerator can bridge the gap. For greater periods the ordinary type of receiver can be used.

The high-and-low-pressure turbine is used under conditions slightly different from either the low- or the mixed-pressure turbine. It is used when during a long period, say three or four months, there is a sufficient supply of low-pressure steam to carry the load on the turbine, but during the remainder of the year there is no low-pressure steam available, making it necessary to carry the load on high-pressure steam alone. This turbine operates strictly as a straight low-pressure turbine under the first condition and differs from a mixed-pressure turbine in that it cannot carry the load on both high- and low-pressure steam at the same time.

Under the second condition it operates strictly as a high-pressure condensing turbine.

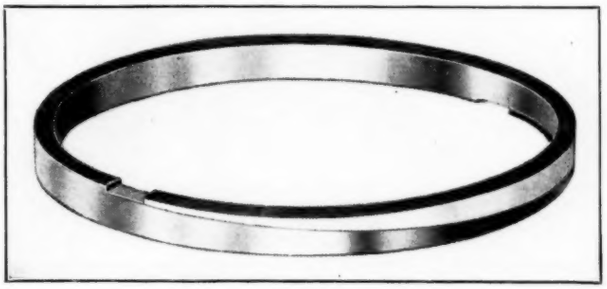
When designed as stated, the turbine does not operate at maximum efficiency at either the high- or the low-pressure condition. The steam consumption at low pressure is increased about 5 per cent. and at high pressure often as much as 15 per cent. For this reason there is always a question as to whether the extra investment necessary for the purchase of one high-pressure and one low-pressure turbine would not be more advisable.

From what has so far been said one might get the impression that the use of an exhaust-steam turbine would be advisable only if the engines already installed are operating noncondensing. Such is not the case. It is possible to increase the capacity of a station 100 per cent. when the engines are operating condensing with about 30 per cent. advance in operating expense. This arrangement is not economical unless the normal output of the combined set is increased 50 per cent. above that of the engine alone and unless the vacuum is increased. Usually this combined set is arranged so that the engine carries its full load under a slight back pressure. Curves such as Fig. 11 should be drawn from which to obtain this information. These particular curves were made for an engine delivering 207 hp., condensing, and are based on maintaining the horsepowers of the engine constant. By reference to chart notice that at 19 lb. abs. back pressure, or about 4 lb. gage, the combined capacity of the engine and turbine would be raised from 230 to about 400 brake horsepower, an increase of 84 per cent., with an increase of total steam of from 3,200 to 5,000 lb., or an increase in total steam of only 56 per cent. In other words, an increase of 84 per cent. in horsepower was brought about at an increase of 56 per cent. in total steam. From this, of course, must be deducted the operating, insurance, etc., cost of the new turbine, condensers and auxiliaries—5 per cent.

This gain was due to the use of a higher vacuum than was economical or possible with the engine, a change made possible by the use of the turbine, and it should be borne in mind that without this increase in vacuum the change from a condensing engine to a noncondensing engine with a low-pressure turbine will hardly warrant the expense.

Inland Piston Ring

The Inland internal-combustion engine one-piece piston ring is an attempt to combine the merits of both concentric and eccentric piston rings. It is made by cutting a continuous ring spirally for half its circumference,



INLAND PISTON RING

as shown in the illustration. It is then heat-treated so that the free ends will hug together. The ring is designed to remain a circle, within and without, at all stages of expansion with the radial pressure equalized. It is strongly made, and breakage during installation is practically eliminated. The rings are made by the Inland Machine Works, St. Louis, Mo., in sizes from 2½ to 71½ in. diameter and in various widths.

Pipe-Flow Formulas Compared

Comparison of pipe formulas by different authors, indicating their common origin in the equation

$$H = f \frac{V^2}{2g} \times \frac{4L}{d}$$

is made in the accompanying table. Group 1 has a fixed value for f without regard to the pipe diameter, while Group 2 varies the constant f with the pipe diameter, making it to equal a new constant,

$$f = K \times \left(1 + \frac{3.6}{d}\right)$$

Except for the difference in the numerical value given for this factor, there is a marked similarity, especially in those of a given group.

COMPARISON OF FORMULAS FOR THE FLOW OF STEAM

	Author	V = Velocity, Feet per Minute	W = Weight, Pounds per Minute	P = Drop in Pressure, Pounds per Square Inch	d = Diameter, Inches
Group I	Geipel and Kilgour.	$V = 9{,}240\sqrt{\frac{Pd}{yL}}$	$W = 50.2\sqrt{\frac{Pyd^5}{L}}$	$P = 0.0003960\frac{W^2L}{yd^5}$	$d = 0.2087\sqrt[5]{\frac{W^2L}{Py}}$
	Gutermuth.....	$V = 9{,}722\sqrt{\frac{Pd}{yL}}$	$W = 53\sqrt{\frac{Pyd^5}{L}}$	$P = 0.0003557\frac{W^2L}{yd^5}$	$d = 0.2032\sqrt[5]{\frac{W^2L}{Py}}$
	Hawksley.....	$V = 9{,}976\sqrt{\frac{Pd}{yL}}$	$W = 54.4\sqrt{\frac{Pyd^5}{L}}$	$P = 0.0003370\frac{W^2L}{yd^5}$	$d = 0.2010\sqrt[5]{\frac{W^2L}{Py}}$
	Martin.....	$V = 10{,}350\sqrt{\frac{Pd}{yL}}$	$W = 56.5\sqrt{\frac{Pyd^5}{L}}$	$P = 0.0003133\frac{W^2L}{yd^5}$	$d = 0.1930\sqrt[5]{\frac{W^2L}{Py}}$
	Hurst.....	$V = 10{,}360\sqrt{\frac{Pd}{yL}}$	$W = 56.5\sqrt{\frac{Pyd^5}{L}}$	$P = 0.0003126\frac{W^2L}{yd^5}$	$d = 0.1990\sqrt[5]{\frac{W^2L}{Py}}$
Group II	Babcock.....	$V = 15{,}950\sqrt{\frac{Pd}{yL\left(1+\frac{3.6}{d}\right)}}$	$W = 87\sqrt{\frac{Pyd^5}{L\left(1+\frac{3.6}{d}\right)}}$	$P = 0.0001321\frac{W^2L\left(1+\frac{3.6}{d}\right)}{yd^5}$	.....
	Unwin.....	$V = 16{,}050\sqrt{\frac{Pd}{yL\left(1+\frac{3.6}{d}\right)}}$	$W = 87.5\sqrt{\frac{Pyd^5}{L\left(1+\frac{3.6}{d}\right)}}$	$P = 0.0001306\frac{W^2L\left(1+\frac{3.6}{d}\right)}{yd^5}$	.....
	Carpenter.....	$V = 16{,}050\sqrt{\frac{Pd}{yL\left(1+\frac{3.6}{d}\right)}}$	$W = 87.5\sqrt{\frac{Pyd^5}{L\left(1+\frac{3.6}{d}\right)}}$	$P = 0.0001306\frac{W^2L\left(1+\frac{3.6}{d}\right)}{yd^5}$	.....
	Ledoux.....	$V = 442\sqrt{\frac{(P_1^{1.94} - P_2^{1.94})}{y^2L}}$	$W = 2.44\sqrt{\frac{(P_1^{1.94} - P_2^{1.94})d^5}{L}}$	$P_1^{1.94} - P_2^{1.94} = 0.1669\frac{W^2L}{d^5}$	$d = 0.699\sqrt[5]{\frac{W^2L}{P_1^{1.94} - P_2^{1.94}}}$

P_1 = Initial pressure lb. per sq.in. abs.; P_2 = Final pressure lb. per sq.in. abs.; $P = P_1 - P_2$ = Drop in pressure in sq.in.; W = Weight of steam flowing, lb. per min.; L = Length of pipe in ft.; d = Diameter of pipe in inches; y = Mean density, lb. per cu.ft.

Automatic Feed-Water Weigher

By Charles Watt Smith

In an endeavor to obtain something more accurate for feed-water measurements, the design shown in Figs. 1 and 2 was evolved.

To illustrate the method of operation, suppose one tank is emptying and the other filling. Valves *B* and *C* are open and *A* and *D* are closed, and relay arm *G* is making contact at the left (Fig. 2). When the tank is full the scale beam rises, making contact at *E*. This completes the relay circuit and swings the arm *G*, pivoted at *H* and carrying two contacts, to the right and reverses the direction of the current through the solenoids controlling all the valves, and *A* and *D* are opened while *B* and *C* are closed and the process is repeated. Care must be taken that the discharge openings *B* and *D* are large enough to empty each tank before the opposite one fills and shafts the relay. Either a mechanical or electrical tally counter may be used.

The tanks should be fastened to the scales and have sloping bottoms, or by elevating them from the scales the outlets may be placed on the bottom to insure constant tare. To insure noninterruption of service the current should be taken from a battery if one is available. The scale beam itself may be used to complete the circuit at *E* and *F*, or better still, a contact soldered on and the scale adjusted for the extra weight.

For the relay contacts clips should be used, or at least some method of holding the relay arm in position after contact has been broken at *E* or *F*. If it is desired to save current, a mechanical trip may be placed on the valve stems to cut off the current when they are closed but still allow the circuit to be completed to open them. This would have the additional advantage of eliminating the magnetic force on valves *B* and *D* when closed, from the final readings. However, as this force is both constant and readily measurable, it is easily taken account of in the tare.

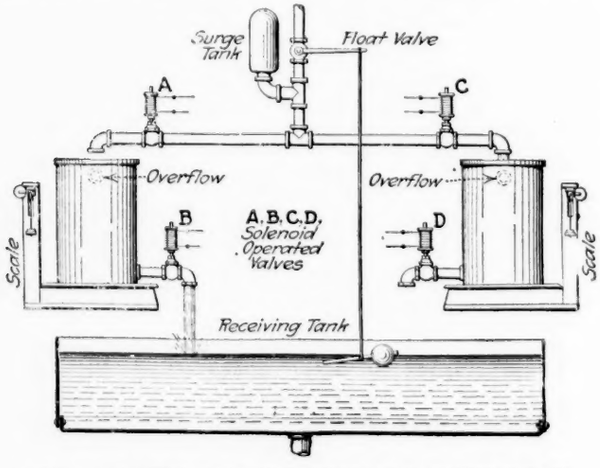


FIG. 1. TANKS AND ELECTRICALLY CONTROLLED VALVES

With proper adjustment the valves might be kept open simply by friction and thus eliminate all current except for opening and closing, but this is a delicate adjustment and may be unreliable.

The principal element of error is in the time of closing the valves *A* and *C*. It is obvious that at high velocities more water will pass into the tank after the valve starts to close than at low velocities. For this reason, if great accuracy is desired, a calibration curve should be made, using cycles per unit of time as abscissas and pounds per cycle as ordinates.

One valuable feature of this apparatus is its ease of calibration, for when it is desired to make a calibration of one tank, the solenoid controlling the outlet valve is disconnected while the tank is filling, so that when the relay is tripped and the current reversed, this valve will remain closed. The beam weight may then be pushed out till the scale balances, giving the exact weight of the water contained. The connection to the solenoid is then replaced, the valve is opened, and the operation is resumed. To obtain various rates of flow, the float valve may be blocked in any desired position. If the valve stems are drilled to take handles in the same manner as the ordinary quick-opening valves, the whole apparatus may be placed on a hand-operated basis in short order. The overflow pipes must discharge into a waste, but of course without a rigid connection to it.

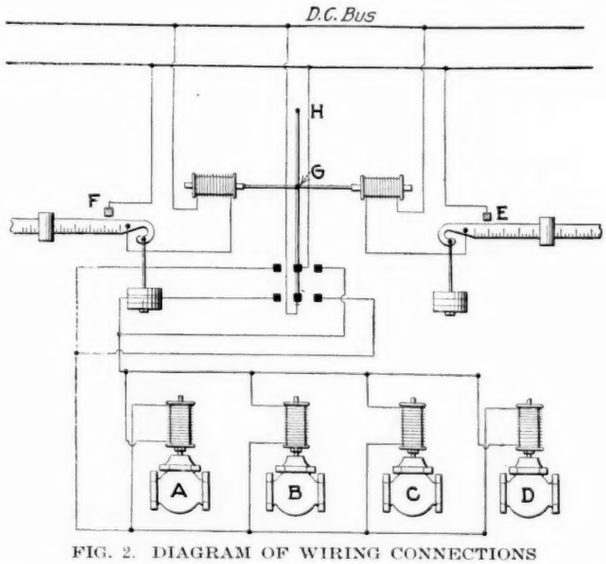


FIG. 2. DIAGRAM OF WIRING CONNECTIONS

Horsepower of Belts

Belt Speed in Ft. per Min.	Width of Belt Used: 2	3	4	5	6	8	10	12	14	16	18	20
	Horse Power That Can Be Transmitted											
400	1	1½	2	2½	3	4	5	6	7	8	9	10
600	1½	2¼	3	3¾	4½	6	7½	9	10½	12	13½	15
800	2	3	4	5	6	8	10	12	14	16	18	20
1,000	2½	3¾	5	6¼	7½	10	12½	15	17½	20	22½	25
1,200	3	4½	6	7½	9	12	15	18	21	24	27	30
1,500	3¾	5¼	7½	9½	11¼	15	19	23	26½	30	33¾	38
1,800	4½	6¾	9	11¼	13½	18	22½	27	31½	36	40½	45
2,000	5	7½	10	12½	15	20	24½	30	35	40	45	49
2,400	6	9	12	15	18	24	30	36	42	48	54	60
2,800	7	10½	14	17½	21	28	35	42	49	56	63	70
3,000	7½	11¼	15	18¾	22½	30	37½	45	52½	60	67½	75
3,500	8¾	13	17½	22	26	35	44	52	61	70	79	88
4,000	10	15	20	25	30	40	50	60	70	80	90	100
4,500	11¼	17	22½	28	34	45	56	64	78	90	102	112
5,000	12½	19	25	31	38	50	62	76	87½	100	112	125

To find the belt speed, in feet, multiply pulley diameter by 3 1/7 or 3.1416 as you prefer. If diameter is in inches divide by 12 to get feet. Multiply this by the revolutions per minute.

Given the Height of Fall, To Find the Velocity due to the height, multiply the height in feet by 64.32 and extract the square root of the product. The root is the velocity in feet per second. Or multiply the square root of the height in feet by 8.025, and the product is the velocity in feet per second. Expressed as a formula, or $V = \sqrt{2gh}$, or $V = \sqrt{64.32h}$, or $V = 8.025\sqrt{h}$, or in round numbers $V = 8\sqrt{h}$.

The Bailey Boiler Meter

SYNOPSIS—When conditions are right, a given boiler with a given fuel ought to make a certain amount of steam for a given amount of air fed to the furnace. This meter gives an indication and record of the relation of air supplied to steam produced, as well as of the condition of the fuel bed.

Combustion, as we know it in boiler furnaces, is the chemical combination of carbon and hydrogen with oxygen. The carbon and hydrogen are the combustible components of the coal or oil; the oxygen comes from the air. If the carbon or hydrogen were as common as the air and we had to hustle for the oxygen, we should probably call the oxygen, or the air supplied, the fuel.

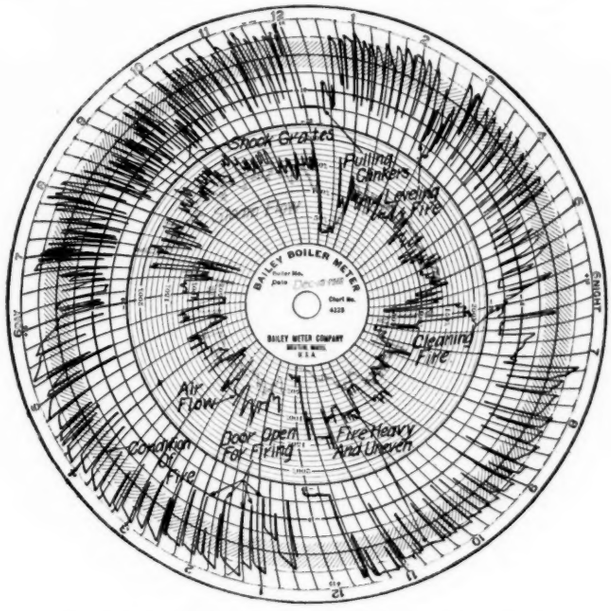


FIG. 1. CHART RECORD FOR 500-HP. BOILER, HAND-FIRED

The outer blue record shows the condition or thickness of fuel bed. The fire is too thick when the record is above the shaded band, all right when on the band and too thin when below the band. Note the drop due to opening the fire door at each firing, the higher reading after more coal is added and the gradual burning down of the fire which takes place more rapidly with the higher rates of air flow

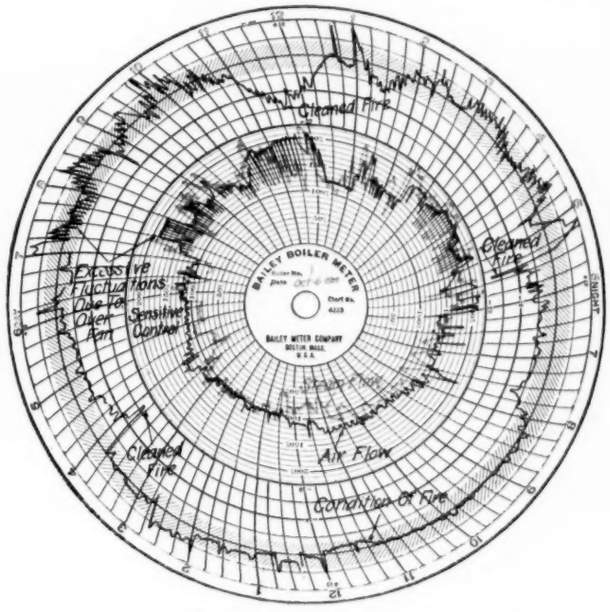


FIG. 2. CHART RECORD FROM 600-HP. BOILER WITH TAYLOR STOKER

The speed of the forced draft fan supplying air to this stoker is automatically controlled by a butterfly valve and damper regulator. The boiler is also equipped with a balanced draft system. Note the extreme and frequent fluctuations in rate of air flow due to over-sensitive regulation. Note the uniform and fairly good conditions through the night, also the effect of cleaning fire at 4 a.m. noon and 5 p.m.

Under given conditions a given quantity of air will burn a certain weight of coal, and this weight of a given coal should evaporate a certain amount of water. Hence there should be a certain evaporation per pound of air. In fact the amount of steam that should be evaporated per pound of air is much more nearly independent of the kind and quality of fuel being burned than one would naturally think. If, then, we can measure simultaneously its air input and its steam output, we shall have a fair indication of how nearly a given boiler is doing to what might be expected of it.

Another indication of practical use to the fireman is the condition of the fuel bed. The best measure of the fuel bed condition is obtained from its resistance to the flow of air by utilizing the draft pressures. This should not be confused with a mere draft reading nor even the differential draft between the ashpit and the firebox, for the differential draft varies with the rate of flow of air as well as the resistance of the fuel bed. By combining the differential draft across the boiler with the draft across the fuel bed the effect due to the rate of flow is eliminated and an indication is obtained that varies with the resistance and shows whether the fire is too thick, too thin, contains holes or is choked up with clinkers.

The Bailey boiler meter furnishes these three indications. Upon a chart, such as is shown in Figs. 1 and 2, are three pens. The red record shows the quantity of steam being delivered by the boiler at any time; the inside blue line the amount of air entering the furnace. The instrument is so adjusted that for the best results with a given boiler and fuel the pens which draw these lines should travel together and their markings superpose. The nearer the blue and the red line come to running together, the better the performance. If the air supply increases without a proportionate increase in the steam output, as will be the case with a too thin fire or a hole in the fuel bed, the air-flow pen is above the steam-flow pen; if the fire is too thick, so that there is less air than is required for complete combustion, the air-flow pen will be below the steam-flow. The outside pen indicates the condition of the fuel bed and furnace, and it is the study of the fireman, by regulating the condition and thickness of the fire, to keep this pen upon the shaded track. Figs. 1 and 2 show the records for hand-firing and a Taylor stoker, respectively.

The mechanism by which this is accomplished is shown diagrammatically in Fig. 3, the steam-flow metering apparatus being shown in red, the air-flow in blue and the

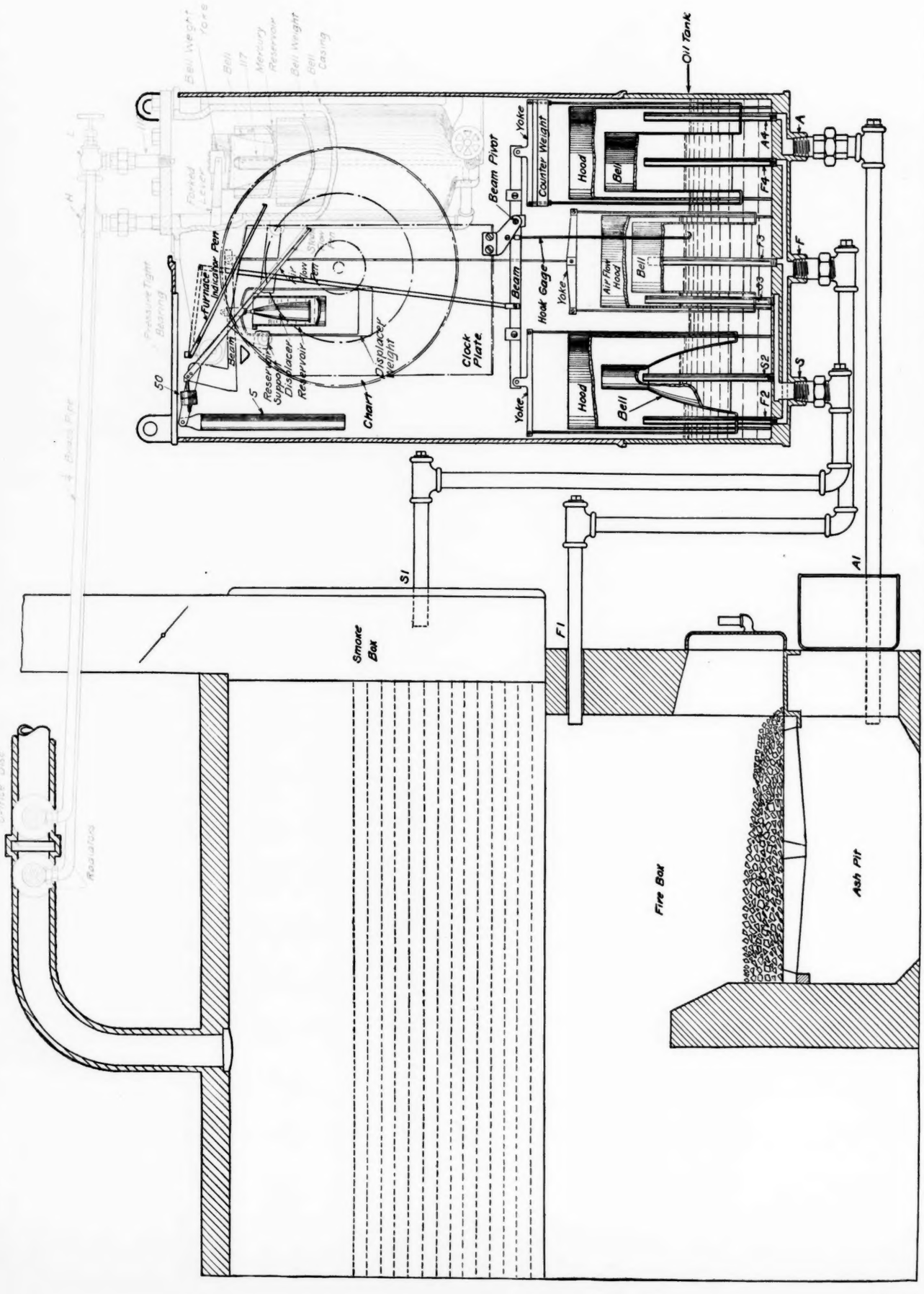


FIG. 3. DIAGRAMMATIC SECTIONAL VIEW OF BAILEY BOILER METER AND RETURN-TUBULAR BOILER, SHOWING PIPE CONNECTIONS AND OPERATION OF METER

furnace indicator parts in black. The steam-flow meter was described in detail on pages 534 *et seq.* of the Apr. 18 issue.

The air-flow part of the meter is operated by the difference between draft pressures in the firebox and in the smokebox (where the gases leave the boiler and before reaching the damper). This is equivalent to considering the resistance of the tubes or gas passages of the boiler as an orifice and using the drop in draft pressure across the boiler to operate the air-flow pen.

It is not intended that this air-flow reading should be a measure of the rate of flow of air in terms of cubic feet or pounds, but as previously explained, it is a measure of the rate of air supplied in terms of what it should

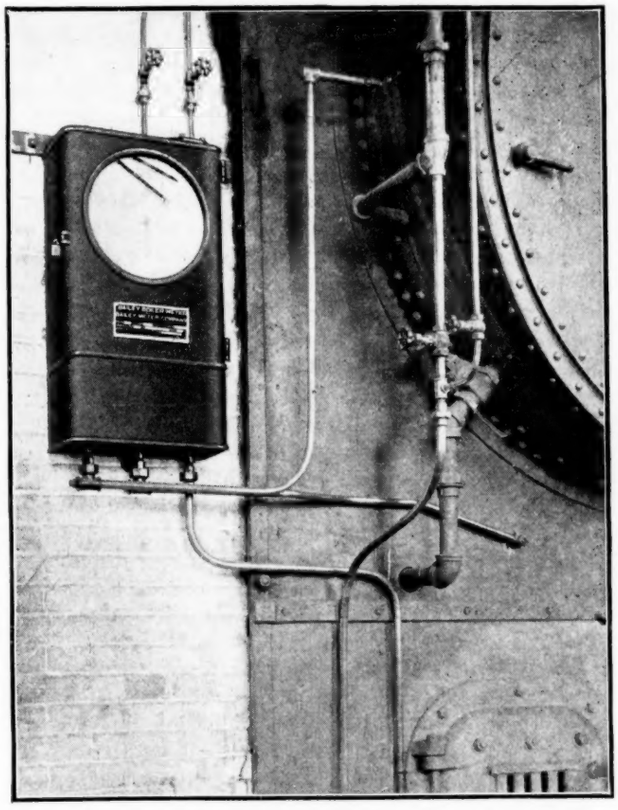


FIG. 4. AS THE METER APPEARS ON BOILER FRONT

be for corresponding rates of steam flow and is determined from actual tests on each individual boiler equipped with a meter.

Fig. 3 shows the air-flow part in blue, with sufficient detail to bring out the principle of its operation. It consists essentially of a bell which has its lower end open and sealed by oil contained in the oil tank. A hood over this bell forms an inclosure so that the smokebox pressure may be applied to the outside of the bell through connection *S* and branch *S-3*. Firebox pressure is transmitted to the meter through connection *F* and to the inside of the air-flow bell by branch *F-3* so that the pressure drop across the boiler is effective over the cross-sectional area of the bell, tending to push it upward. This bell is pivoted on the air-flow beam by means of rods and a yoke. The beam, which is of an L-shape to clear the pressure-tight bearings, is pivoted to the arm of the steam-meter casing, the main counterweight 5 and smaller counterweights 50 being for the purpose of balancing and adjustment. As the pressure across the bell is increased, it lifts the bell, and the outer end of the beam rises and carries with it a special-shaped displacing member which is hung from a pivot on the beam. This displacing member is submerged in mercury contained in its reservoir, so that as the beam rises the displacing member is drawn out of the mercury and the buoyant effect is correspondingly changed by an amount that will exactly balance the pressure difference. The shape of this displacing member is such that the air-flow pen will move in proper relation to the pressure difference between *F* and *S*.

The drop in draft pressure across the boiler, as measured between the firebox and the smokebox, varies with the rate of flow of air, as previously explained in connection with the air-flow part of this meter. This furnace indicator operates upon the principle of combining the pressure drop across the fire and the pressure drop across the boiler so as to eliminate the effect due to the rate of flow of air and obtain a net result which varies only with the resistance of the fuel bed.

Mechanism of the Furnace Indicator

In Fig. 3 the furnace-indicator parts are shown in black. The right-hand bell is supported from a knife-edge pivot on the end of the beam. This bell has a hood over it so that ashpit pressure is applied on top of the bell through connection *A* and branch *A-4*. The firebox pressure is conducted to the inside of the bell through connection *F* and branch *F-4*, hence the difference in pressure between the ashpit and firebox tends to pull downward. Another bell of special shape is supported from a pivot on the left-hand end of the beam. This bell also has a hood so that the firebox pressure is applied through connection *F* and branch *F-2* to the outside of the bell. Smokebox pressure is applied to the inside of the bell through connection *S* and branch *S-2*, hence the pressure difference between the firebox and smokebox is effective over the area of the bell at the surface of the oil in the tank and produces a downward force. The beam is supported on knife-edge bearings which are carried by a frame. This frame is adjustably supported on the clock-plate so that the length of lever supporting the left-hand bell may hold a certain ratio to the length of lever supporting the right-hand bell. The moments produced by the two pressure differences *F* minus *S* and *A* minus *F* are proportional to the effective areas of the two bells and their respective levers or moment arms. So long as the desired relation exists between the resistance of the fuel bed and the resistance of the boiler, there will be a certain relation between these two pressure differences, the forces produced by them on the two bells will exactly balance each other, and there will be no motion regardless of changes in the intensities of the pressures. But should the fuel bed become too thick, the pressure difference across it will become relatively greater than the pressure difference across the boiler, and the equilibrium between the two bells will be upset owing to the preponderance of force exerted on the right-hand bell. This will result in the variable-area bell being drawn up, thereby presenting a larger area at the surface of the liquid, and this greater area over which the pressure drop across the boiler is effective will balance the increased pressure drop across the fuel bed, so that motion of the bells necessary to restore the equilibrium is a measure of the change in the resistance of the fuel bed. The motion of the bells and of the

beam is transferred to the furnace-indicator pen by means of a connecting-rod and arm, which is pivoted to the main casting just above the pressure-tight bearings. If the fuel burns thin, the pressure drop across it is relatively less, so that the variable area bell moves downward until the smaller effective area at the surface of the oil restores equilibrium.

This apparatus is the invention of E. C. Bailey and is furnished by the Bailey Meter Co., 141 Milk St., Boston, Mass. Fig. 4 shows its appearance on the front of a boiler.

Crane Wheel and Gear Puller

One of the annoying jobs that comes up in power-plant work is the removing of gears and pulleys from the auxiliaries. To facilitate such work the wheel and gear puller, Fig. 1, is being manufactured by the Crane Puller Co., Arlington, Mass.

The device is made with a three-arm head, the center of which is tapped for a long threaded screw. From

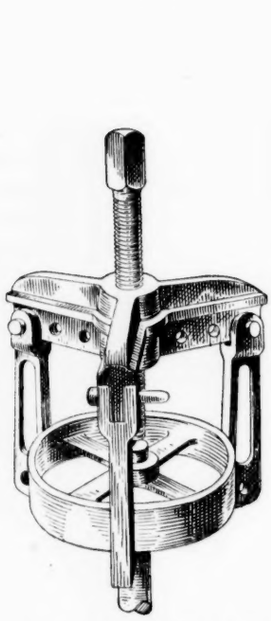


FIG. 1. WHEEL PULLER

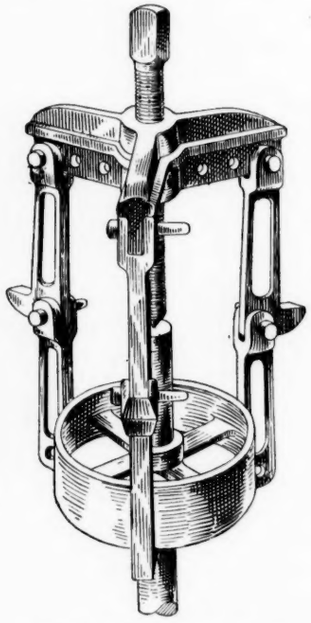


FIG. 2. EXTENSION ARMS

each arm a puller arm is hung, being pivoted at the top end and having at the lower end a projection for fitting to the rim of the pulley. When the screw is tightened the force exerted tends to pull the pulley from the shaft. A set of extension arms, Fig. 2, is provided for work beyond the reach of one set.

Welded Pipes Are Made by the lap- or butt-weld process, differing, as the terms indicate, in the form of the joint, or weld, extending the length of the pipe. Since a comparatively larger welding surface is obtained by the lap-weld process, it is usually found to be stronger than the butt-weld and as strong at the weld as at any other place. Butt-welding is performed in a manner similar to lap-welding except that the edges of the "skelp" are slightly beveled off at the inside edge, the outside being a little wider than the inside, so that the edges will come squarely together when formed. The weld is usually accomplished by pressing the two edges together while at a welding heat, producing a reduction in the size; or, in other words, the original tube is made oversize and compressed by rolls and rings to the correct diameter and finish. Butt-welding is the practice in making pipe up to about 3 in. diameter and lap-welding for all larger sizes.

Smoke Abatement at Boston

Violations of the Boston smoke law continue to decrease in proportion to the total number of observations, according to the forthcoming annual report of the Massachusetts Gas and Electric Light Commission. Five years of smoke inspection by the board is now concluded, and the percentages of observations in which violations have been found from year to year are as follows:

	1911	1912	1913	1914	1915
Stationary stacks	15.5	5.6	3.3	3.3	1.5
Locomotive stacks	3.5	4.7	3.4	2.7	1.0
Marine stacks	10.0	3.8	7.0	7.6	3.4

Fluctuations in the number of violations observed are influenced by the advent of unfavorable weather conditions, variations in the quality of fuel available to plant owners, and other factors; but the decreased number of violations indicates the good results of the inspection system maintained, together with the coöperation of fuel users in the Boston district. Besides Boston, the district includes Brookline, Cambridge, Chelsea, Everett and Somerville.

In the past five years the inspectors of the board have made 175,603 recorded observations, of which 131,849 were upon stationary stacks.

The number of recorded violations of the smoke law due to careless operation of stationary stacks in the past four years totals 3,146, those in 1915 being 643, the smallest number in the records of the commission. In the past four years the total number of recorded observations of stationary stacks violating the act on account of overloading the plant was 601, of which 109 were in 1915, again the smallest recorded. The following table gives the number and classification of stationary stacks upon which observations have been made yearly:

	1911	1912	1913	1914	1915
Public service	53	52	115	126	130
Manufacturing plants	455	650	485	605	646
Office buildings	253	435	297	351	388
Residences	11	4	2	..	3
Total	772	1,141	899	1,082	1,167

The stationary stacks upon which recorded observations showed smoke emitted in excess of the amount allowed by the act are classified as follows:

	1911	1912	1913	1914	1915
Public service	12	11	64	21	23
Manufacturing plants	388	212	225	194	153
Office buildings	74	64	76	99	90
Residences	1	..	2	..	..
Total	475	287	367	314	266

The total number of recorded violations by stationary stacks due to careless operation in the past four years was 3,146. At the end of the fiscal year 1915 not a single stack at which a violation had been recorded was a continuing offender.

In the past five years the board has received 26 complaints and has held 17 public hearings. There have been three prosecutions for violations of its orders relative to smoke abatement.

Warren A. Edson is chief smoke inspector of the commission.

Location of Switchboard—It has been customary to erect the switchboard in the engine room and almost directly over the generating plant. It is now being realized in modern large power houses for generating extra high-tension energy that the switchboard operator should not be disturbed by any mishap in the engine room or in the boiler house. In one large power house recently erected, the switchboard building and all the gear in connection with it are quite one hundred yards from the generating station proper.—W. W. Lackie.

Editorials

Alcohol as Fuel

"Necessity is the mother of invention," as the saying goes. The high price of gasoline has created the necessity, and inventions of substitutes appear to be coming along at the rate of about one a week since Louis Enright, of Farmingdale, L. I., proclaimed to the world the magic of his green powder and water.

Passing these nostrums with the comment that it is up to their promoters "to make good or stop prattling," serious attention may well be given to such fuels as kerosene and alcohol. The former is comparatively cheap and is widely used with good results in engines of the hot-bulb type, but it still seems to be awaiting a satisfactory carburetor adapting it to the service required of the automobile motor. Alcohol, on the other hand, is expensive and its cost has heretofore kept it from competition with gasoline. Now that the price of the latter has reached such a high mark, with indications of going still higher, alcohol is again being talked of. Although selling at present at about twice the price of gasoline, investigations have indicated that under favorable conditions it could be produced and sold for much less than the present retail price of gasoline. In fact, before the war it was being sold in Germany for about twenty cents a gallon.

When used in an ordinary gasoline engine, about one and one-half times as much alcohol per horsepower-hour must be used as gasoline and the maximum output of the engine is slightly decreased. If the compression be raised to about one hundred eighty pounds, however, the consumption per horsepower-hour will be cut down to that of gasoline and the output of the engine will be increased.

The suggestion is often heard that farm refuse might profitably be employed in the production of alcohol. It is true that partly decayed fruit and vegetables, and grain that is not fit for the market but that is high in alcohol, might be utilized; but it appears that the still would have to be of fair size to make the venture profitable, especially in view of the Government red tape, even though the product be denatured. In order to make a high grade of alcohol, the investment is said to be relatively high, but a grade eighty per cent. pure can be produced at comparatively small cost and, moreover, is satisfactory as fuel in an internal-combustion engine.

About eight years ago the Department of Agriculture made an effort to interest the farmer in the production of alcohol, but met with little success as the proposition at that time was not attractive in view of the low price of gasoline. Now that the conditions have changed, it may be an opportune time for another attempt. It probably would not be practical commercially for the individual farmer to enter into the business of alcohol production; his overhead would be too great. However, there might be established community stills to which farmers in the section would bring their refuse products just as they now bring their milk to the creamery.

Of course one must consider that gasoline will probably drop slightly in price when the present export demand, created by the war, has let up; also that the large margin of profit will permit the big oil companies to lower the prices to meet competition and still make money. The rule of supply and demand in fixing prices can be broken only by competition, and it is a question whether it is commercially feasible for alcohol to furnish this competition.

Technical Preparedness

A great deal has been written about educating the practical man. In fact this message of how to know more and, by knowing more, earn more, has been sent forth to the operating man on about every imaginable literary vehicle, yet much remains to be done. Operating men over all the country are finding themselves unable to meet the demands laid upon them by the new, improved and more efficient equipment, which requires a good deal of why and wherefore knowledge for its successful operation. To properly handle any plant today the man responsible must know the relation between pounds of coal fired and pounds of water evaporated, the relation between pounds of steam to the cylinder of the engine and kilowatt-hours at the switchboard, etc. All this is necessary, for sooner or later he will have to show the management that he is producing power as cheaply in the engine room as the central station can supply it.

This naturally brings up the question, How can the engineer best prepare himself? This is the big problem; there are a great many things that can be done, and different situations are met in different ways. One thing that will greatly assist and probably has done more than anything else is technical reading, both of periodicals and books.

Here is one of the vital parts of the problem—selecting the right technical literature. Books and papers are just as much engineers' tools as wrenches, hammers or cold chisels, and it takes practice to successfully manipulate them. We have all probably laughed at the novice's first attempt to use a monkey wrench. A beginner can be just as clumsy with the books that he consults to assist him in solving his problem. Just as it took considerable time to acquire skill in handling the tools about the plant, it also takes a lot of time to acquire the knack of getting information out of books. Information, like everything else worth while having, can be obtained only by real effort. One cannot expect to work along without study and when the occasion arises go to the public library and pick up the book one wants and have it shout out "Mister, here is your answer!"

A complaint often heard is that many books are hard to understand. It is true that some do appear to have been written to display the author's erudition rather than to assist the reader. There are, however, many good books that have been carefully arranged and worded so as to help the reader to meet and solve his problem, but

at their best they do not shout out their contents. Their information must be sought after, and this by diligent and assiduous study. It is after all another instance of the truth that one cannot get something for nothing.

The Metric System

Among the powers conferred upon the Congress by the Constitution is that "to coin money, regulate the value thereof, and of foreign coins, and fix the standards of weights and measures."

There are now pending in the Congress two bills—one, H. R. 528, introduced by Congressman Johnson, of Washington, establishing the centigrade scale of temperature measurement as the standard for United States Government publications, and the other, H. R. 151, introduced by Congressman Dillon, of South Dakota, establishing the metric system as the sole standard of weights and measures for the United States and imposing a penalty of $500 fine or three months' imprisonment, or both, for the use or attempted use of any other.

It is unfortunate from the mathematical point of view that our ancestors did not have twelve or sixteen fingers. When they began to count, their fingers were the natural implements, and our decimal system of notation, progressing by tens, is the result. But ten can be halved only once with an integral result; the second halving gives a fraction. Twelve may be halved twice, giving six and three, and the English unit of dimensional measurement, the foot, was therefore divided into twelve equal parts. Sixteen is better still. It can be successively halved away down to unity—eight, four, two, one—and the English unit of measure of weight, the pound, was divided into sixteen equal parts.

If we could start all over again with a clean page, the thing to do would be to make a system of notation with sixteen digits including the cipher, adopting new single characters for the numbers from ten to fifteen inclusive. The character 10 would mean as many as our present 16, it and its multiples could be successively halved away down to unity, and all the simplicity of multiplication and division by shifting the decimal point would be preserved. As it is, we have a decimal system as exemplified in our own currency and in the weights and measures of the metric system, and the duodecimal and other systems as exemplified in the English shilling and foot and other units.

Notwithstanding the common use in the United States of the English system of weights and measures, the fundamental standard of length in this country is the international meter. By an act of Congress of July 28, 1866, the relation of "one meter equals 39.37 inches" was legalized. In Great Britain one meter equals 39.370,113 inches, so that the English foot, yard, mile, acre, etc., are different from our own.

Fortunately electrical measurements are expressed in one system, the metric, the world over. Physicists and chemists work with the rational centigrade temperature scale and largely in metric units. Much of the work of the Bureau of Standards is already done in metric units. How much will the usefulness and popularity of the rest of its work be affected by being expressed in these units if the popular use of the other system continues?

The renouncing of the unscientific scale of Fahrenheit, with its base at the lowest temperature which he could happen to get, would be a step in the right direction. But this would mean the making over of our tables of the physical properties of steam, ammonia, etc., and if we make them over, shall we make them with centigrade-pound values or go directly to centigrade degrees, kilograms per square centimeter, and kilogram-meters?

A rational step in this direction might be the extension of the purely scientific uses of the metric system to such engineering measurements as temperature, energy, thermo-dynamic calculations, etc. The making over of the tables of physical properties of steam would afford a needed opportunity for standardization. Of the half-dozen tables in existence, no two agree, because one author uses the average value of the specific heat between 32 and 212, another the specific heat at 62 degrees, and another at the point of maximum density. One uses 778 foot-pounds as the equivalent of a British thermal unit, and another 777.52, which is incorrect in the second place of decimals on his own premises. One includes in the total heat of the steam the heat equivalent of the feed-pump work, and others do not; some use the old Regnault, others the newer values of total heat. The differences are for the most part academic and not of a magnitude to be of practical importance, but a movement which would compel the making of a new table based upon universally recognized fundamentals would not be altogether a misfortune.

Uniformity is desirable, but it is hard to change all at once the habits of thought of one hundred millions of people, to overcome the incredible inertia of established fact; and the effort involved in reading and study would be enhanced temporarily even if it were eventually reduced by the sudden enforcement of a new scale of measurement. Congress may legislate that the people must use meters and kilograms, but they will continue to think in feet and pounds. The transposition will be gradual and may perhaps be better worked out by feeding the new units to the public in weather reports, governmental papers, etc., than by fining an old lady five hundred dollars for trying to buy tea by the pound.

When the little molecules in the parts of machinery are crowded and compressed by the bending or pounding or strain of the parts which they compose, they get fatigued—sort of feel like you do after standing a thirty-six hour watch. And when they have been on watch too long, they fail and break down, just as you would do.

An engineer recently said to us that gaudy paints and stripes and luminous brass rails on and around power-plant machinery made him think of a cheap apartment house. We agree. What looks nicer than that deep green or black with polished steel tubing as railing?

Deep down in your manly bosom resolve that you will follow-up leaks and the weak places so closely that Sunday work will be reduced to a minimum during the hot months. The men, your wife and the kiddies will appreciate it.

Now, while you think of it, turn the calendar over to September and make a note thereon that those radiator valves should be packed.

Correspondence

Heat Maladies of Marine Diesels

A presentation of the attitude of those who favor the two-stroke cycle in marine Diesel-type engines is afforded by the letter of Mr. Illmer in the Apr. 11 issue. I will first take up the doubts that he casts upon certain statements made by me in an article in the Feb. 22 issue. His direct contradictions of my remarks were:

1. "The statement that the two-stroke-cycle oil engine has proved generally unsatisfactory for marine service is not borne out by the large mass of contrary evidence presented in recent technical literature."

2. "As regards Mr. Crowly's statement that no repeat orders have ever been given for two-stroke-cycle oil engines, this does not appear to square with facts."

3. "Mr. Crowly mistakenly regards this issue as one of the two-stroke- versus the four-stroke-cycle unit, whereas it is one of the high-speed versus the slow-speed engine."

Will Mr. Illmer please give the references to the "large mass of contrary evidence" presented in recent technical literature? I wish to answer that "large mass" specifically.

Meantime, I will mention that the two-stroke-cycle engines of the "Sebastian" have been replaced by four-stroke-cycle engines; the two-stroke-cycle-engined ships "Arum" and "Arabis," both having stepped-piston engines of the Neptune-Polar type, have been refused and have been returned to the builders; the Carels two-stroke-cycle engines of the "Eavestone" have been replaced by steam machinery; the "Primus" with Junkers-type two-stroke-cycle engines, was refused by the Hamburg-American line; a ship with similar engines for the German-American Petroleum Co. was altered to steam; a third ship with Junkers engines was ordered to have steam for Lane & Macandrew; the "Toiler" had her two-stroke-cycle Polar engines replaced by a steam plant; the "Russ" had her two-stroke-cycle engines taken out in favor of Kolomna four-stroke-cycle engines; the Standard Oil Co.'s "Glenpool" (ex "Hagen"), with Krupp two-stroke-cycle engines is laid up for extensive work after practically every voyage; the sister-ship "Loki," until boxed up by the war, was as bad; the "Fordonian," with a Carels two-stroke-cycle engine, had 17 new cylinder heads up to the end of the season 1914, etc. To enter further into the woes of the two-cycle-engined ships would require much space without a corresponding benefit to the reader. In conclusion, however, Rear-Admiral Grant's testimony relative to submarine engines before the House Committee on Naval Affairs may be quoted: "Our entire trouble has been with the two-stroke-cycle engine of the Nürnberg (M.A.N.) type."

When Mr. Illmer states that "a number of leading firms such as Krupp, Schneider-Carels, Sulzer and others now confine their efforts to the building of large two-stroke-cycle machines," he is merely beating the air. (Incidentally, there is a Schneider firm at Le Creusot and there was a Carels firm at Ghent, but there is not, nor has there ever been, a Schneider-Carels firm known to fame.) When Krupp, Carels and others began to build the two-stroke-cycle engines for marine work, no demonstration had been afforded of the failure of this type in marine service. They started along what they apparently considered to be an easy road. Whether they would still be on that road had war not stopped their activities in this direction can only be surmised.

It does not avail Mr. Illmer to have quoted Mr. Batho regarding the Sulzer engines of the "Monte Penedo." My article stated that, "up to the present no two-stroke-cycle engine above 800 b.hp. has satisfied marine conditions, and all except two sister engines of even that relatively low power have had serious troubles." This reference was to the "Monte Penedo" engines, for I was well aware that her machinery has made a presentable showing since her pistons were changed to a new design. I will add that the "Monte Penedo" is helped out very considerably by the fact that she spent about 55 per cent. of her time in port loading and discharging, her trade virtually being coastwise. Were she to make transatlantic voyages regularly, she might do no better than she did on the occasion when she left Europe on her maiden passage.

Mr. Illmer is incorrect in stating that "repeat orders are to be found in the guise of sister ships, of which there are a number, and especially in ships having engines of substantially similar design." The orders for the "Hagen" and the "Loki" were placed at the same time, and the "Wotan" and the auxiliary vessel "France" are under totally different ownerships.

Proceeding to Mr. Illmer's observations in general concerning submarine engines, I can state that it is not true of all submarine oil engines that "the rotative speed and the stress in the working parts must be carried to the limit in order to attain the desired ship speed." Whatever course may have been taken by those upon whom the United States Navy has hitherto had to rely for submarine engines, and whatever Mr. Illmer's experiences in this line may have been, cannot alter the fact that a design of engine is available today free of those undesirable qualities mentioned by Mr. Illmer. It operates on the four-stroke-cycle principle and yet is free from that "additional weight" which Mr. Illmer by implication attributes to all four-stroke-cycle engines.

Evidently in rejoinder to the statement in my article that "in the latest specifications of the United States Navy preference is given to the four-stroke-cycle engines," Mr. Illmer states that he is "unaware that the United State Navy has given official expression as regards the merits of the two- vs. the four-stroke-cycle oil engines for ship propulsion." I think that the fact indicated in my statement is covered by Mr. Illmer's term "official expression," but however this may be, the fact itself is not altered. Right in his own town of Bridgeport it ought to be well known that four-stroke-cycle engines were ordered under the last submarine program.

I preserve an open mind about the two-stroke-cycle engines in the Navy Yard, but I have seen two such

engines, with four cylinders instead of six, after their return from an ocean voyage of 21 days' duration, and they were in need of a very expensive overhaul. Their daily consumption of lubricating oil had been half a ton per day! In later voyages that would undoubtedly be susceptible of reduction, but imagine the conditions that called for such a flood of oil.

There remains in Mr. Illmer's letter only one other point upon which I desire to touch. It appears to have been brought forward in the endeavor to refute the evil influence of the heat conditions on the operation of the two-stroke-cycle engine. J. T. Milton's statement is cited that the average temperature in the two-stroke-cycle Diesel engine is approximately 1,113 deg. F., as compared with 896 deg. F. in the four-stroke-cycle engine running at the same speed. Mr. Milton's consideration of this subject is of course known to everyone who has any interest in these matters, but the limitations thereof are very much less well known. Mr. Milton himself indicates their existence, for after having clearly shown that he calculates the temperature of the gas at various parts of the cycle on the assumption that the gas weight remains constant, he proceeds further to mention that allowance must be made for the weight of air used with the fuel-injection plus the added volume caused by the combustion of the hydrogen of the oil, a total augmentation taken as 10 per cent. by volume. Thereupon he demonstrates that the mean temperature of the gas in a cylinder of the "Suecia" engines (Burmeister & Wain four-stroke-cycle type) is 664 deg. F. Furthermore, one should not be misled by considerations of mean temperatures or mean forces when the maxima are so important. It was not the mean force that broke the Johnstown dam!

I have a right to expect that Mr. Illmer will withdraw whatever contradictions he is unable to substantiate. It is not for him alone that I am concerned, but for many others who are reaching out for the truth and who find difficulty in making their way through articles and papers that have been short of authentic basis.

Jersey City, N. J. R. W. Crowly.

In a letter in the May 9 issue F. O. Lisle criticizes a former article by Mr. Illmer. In certain points I agree with Mr. Lisle, but I desire to correct some of his statements and to answer the question that is raised as to the continuous run of two-stroke-cycle engines. I feel entitled to do this, as I witnessed the practical results obtained on certain European merchantmen and some of the trials were carried on under my supervision.

The maiden voyage of the "Secundus," built by Blohm & Voss in Hamburg, was made in 14 days from Hamburg to New York. Both engines had to be stopped for 20 min. after three days' run, but only because the baffle plates in the funnel, which serves as a muffler, became loose. These were tightened, and the voyage proceeded to New York without a stoppage. Will anyone blame the Diesel engine for this accident?

Another example was the "Rolandseck," propelled by a 1,600-b.hp. two-stroke-cycle Diesel engine, which made her voyages with great regularity.

The "Monte Penedo," equipped with two two-stroke-cycle Diesel engines, each of 850 b.hp., built by Sulzer Bros. in Switzerland, made very successful voyages. Mr. Lisle might raise the point that the number of revolutions per minute of these engines had to be reduced, which means that the engines did not run at full load. This is a fact, but it was necessary because the operating speed was too close to the critical speed.

I have had experience with two- and four-stroke-cycle engines, both single- and double-acting and although maintaining that the four-stroke-cycle engine will always remain the prevailing and the proper engine for certain conditions and certain sizes, I believe the development of the two-stroke-cycle engine can be delayed only, since for marine purposes and particularly for larger outputs it will win sooner or later.

One of the most serious difficulties experienced with the two-stroke-cycle engines is with the bearings. But this is a point which the designer should be able to overcome after now knowing that the strain on the bearings is greater than was formerly expected and figured on. The two-stroke-cycle engine is advisable as a prime mover of large output. Why not go one step further and consider the double-acting two-stroke-cycle engine, which would eliminate the present bearing troubles? Blohm & Voss in Hamburg have been experimenting with this type of engine for several years and have run one on the test floor continuously at full load for seven 24-hr. days. The greatest strain is put on the engine when it is started, and this was done on these engines fifty times or more a day when on the test floor. These engines are now installed on board a ship which has made her trial trips, but cannot be put into commission because of the war.

I think these facts are sufficient to disprove the statement that "only Krupp produced satisfactory two-stroke-cycle engines." This firm made only one or two bronze heads cast in one piece with the cylinder. This head was made of bronze to guard against fracture. However, have we no fractured heads on four-stroke-cycle engines? Where the heads always start to crack is between the openings for the valves, where only little material is left, and it is not very well cooled and is overstrained by the heat. On a four-stroke-cycle engine there are usually at least four such openings, especially on engines of the sizes used for marine work, but there are designs of two-stroke-cycle engines with only two openings in the cover, but not the Krupp engine. As more material can be provided when there are only two openings instead of four, which cover does one suppose will resist the heat best?

Concerning the reference to Mr. Lauster, let it be remembered that although Doctor Diesel conceived the idea of a high-pressure combustion engine the Maschinenfabrik Augsburg-Nürnberg and Mr. Lauster should be given full credit for developing and making the Diesel a commercial engine.

That in Augsburg only four-stroke-cycle engines are built is a matter of organization of that firm, since it was decided several years ago to build in the works in Nürnberg the two- and in the works in Augsburg the four-stroke-cycle engines.

Instead of condemning let us rather unite in our engineering endeavors, to make a success of the Diesel engine in this country—a country where the preliminary conditions are most favorable for the operation of this engine. Every manufacturer may develop his type thoroughly with regard to the requirements in the field and at sea; then the confidence of the buyers, including the ship owners, will be established and there will soon be a great demand for oil engines. H. Schreck.

St. Louis, Mo.

I have just read the article appearing under the heading, "Heat Maladies of Marine Diesels," on page 667 of the May 9 issue of *Power* and take exception to Mr. Lisle's challenge to point out a single case where a two-stroke-cycle Diesel-engined mercantile ship of over 500 b.hp. has made a continuous run at full load for ten 24-hr. days. The "Wotan" has made several such trips, as have also the motorships "Hagen," the "Loki" and the "Eavestone."

On a recent trip to Sweden I had the pleasure of seeing two 1,650-hp. six-cylinder, two-stroke-cycle single-acting marine Diesels built by the Swedish Diesel Engine Co., of Stockholm. These engines operated in every way successfully and have since been installed in a large tankship, and it is certainly to be admitted that an engineer having the number of years' experience that Mr. Hessleman, chief engineer of the Swedish Diesel Engine Co., has had in building both two- and four-stroke-cycle engines, is capable of judging whether the two-stroke-cycle marine engine can be made a success.

Two 1,250-hp. two-stroke-cycle single-acting stationary engines built by Carels Freres, of Ghent, Belgium, have now been in successful operation for a year and a half, as a result of which performance their owners, Phelps, Dodge & Co., have ordered additional engines of the same size and type, as have other large power users, basing their judgment on the performance of these two engines.

I feel that in justice to the oil engine no decision should be taken on two- versus four-stroke-cycle engines from a viewpoint of the types, as the manufacturers are expending a great deal of study and money in developing the engines of the types they are building and deserve consideration for their efforts along this line. There will always be the question of the two-stroke cycle versus the four-stroke-cycle engine, and there will always be fair division of the business between the two types within certain ranges of sizes. However, where larger engines are used they will, beyond question, be the two-stroke-cycle type.

W. R. HAYNIE,
President, The Marine Oil Engine Co., Inc.
New York City.

The Imperial Gallon Used

On page 636, in the issue of May 2, appears a reprint or an abstracted article, "Air-Lift Pumps and Compressor Capacities," in which, near the foot of the page, Free air in cu.ft. per min.

$$= \frac{62.4 \times \textit{cu.ft. of water per min.} \times L}{4{,}869 \times \eta \times \log_{10}\left(\frac{S}{34}+1\right)}$$

is transformed to terms of gallons per minute, and in the next equation is given

$$= \frac{10 \times \textit{gal. water per min.} \times \textit{lift}}{4{,}869 \times \eta \times \log_{10}\left(\frac{S}{34}+1\right)}$$

As the conversion ratio of gallons and cubic feet is 7.48 to 1, is there not some mistake in this reduction, and should not this last equation be Free air in cu.ft. per min.

$$= \frac{8.34 \times \textit{gal. water per min.} \times \textit{lift}}{4{,}869 \times \eta \times \log_{10}\left(\frac{S}{34}+1\right)}$$

If this be the correct reduction, then the following formulas require revision to

$$\frac{\textit{gal. water per min.} \times \textit{lift}}{583.8 \times \eta \times \log_{10}\left(\frac{S}{34}+1\right)}$$

and

$$\frac{\textit{gal. water per min.} \times \textit{lift}}{234 \log_{10}\left(\frac{S}{34}+1\right)}$$

and following "Free air in cu.ft. per min." should be

$$\frac{\textit{gal. water per min.} \times \textit{lift}}{240 \log_{10}\left(\frac{S}{34}+1\right)}$$

instead of 200 as given.

This matter of air-lift pumping is one that I have met with in central-station power work and is a troublesome one to handle because of absence of complete data and good working formulas.

Will you kindly check over my figures and advise me whether the corrections I note are proper?

Williamsport, Penn. G. E. WENDLE.

[All the difficulty comes through our failure to note that the gallons referred to are Imperial gallons, of which there are 10 to the cu.ft. since they contain 277.274 cu.in. as against the U. S. gallon containing 231 cu.in. By applying these values or changing to U. S. gallons, as indicated, the formulas will prove out. This should have been done or else a notation that the *Mechanical World* is an English publication and therefore the formula was based on the Imperial gallon.—Editor.]

Calculating Pump Duty

In the May 9 issue, I noticed the following error in my article, "Calculating Pumping Duty." The final calculation should read as follows:

$$\frac{725 \times 230 \times 9.6 \times 1{,}000}{12} = 133{,}400{,}000 = \textit{duty in foot-pounds per } 1{,}000 \textit{ lb. of steam}$$

instead of 1,334,000,000 ft.-lb., as it reads in the article. I wish to make the correction, as although a zero is nothing, it means a lot if it has the backing in the right place.

E. C. DOLAND.
Arlington, Mass.

Cause of Flickering Lights

With reference to Mr. Bulsara's letter on flickering lights in the Apr. 18 issue, I would suggest that he look to his engines for the trouble. I was similarly bothered some time ago, and overhauled the generator and exciter, but could not find anything wrong. I then started to overhaul the engine and there found the trouble. I had changed the plates on the trip cams a few days before, and there was one that caught a little more than the other, which caused the engine to speed up for half the stroke and slacken on the remainder of the stroke. I adjusted the dashpots by shortening the governor rod and propped the governor at about where it would work at ¾ load and then worked the valves by hand until both were adjusted alike. I have had no more trouble with the lights flickering.

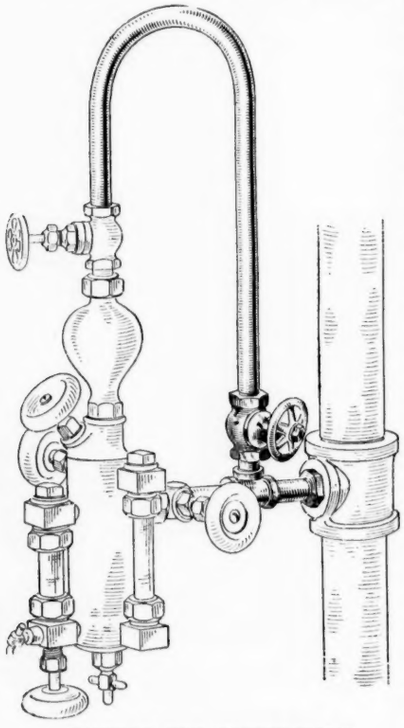
In Mr. Bulsara's case the cause may be in the valves. There may be more lead on the steam ports on one end or more lap on the exhaust ports, which will cause the engine to slacken at the end of the stroke or speed up at the beginning of the stroke. Again, the fiber on the governor trips may be worn more on one side than on the other and cause one of the ports to close sooner than the other.

I wish Mr. Bulsara would let us know through *Power* when he finds the cause of the trouble.

Granby, Canada. A. F. Bolduc.

Double-Connection Lubricator with Single Connection

I once worked as operating engineer in a pulp mill where there were a number of rotary burners for burning soda ash from waste liquor. Each rotary was run by a small steam engine, and it was important that the engine should not be stopped while there was a fire in the furnace, as the cylinder of the burner would become so hot that the ash would melt and stick, necessitating a shutdown of several hours to clean the cylinder. On one of the engines was a single-nection lubricator. One day the fireman reported that it had burst, and I wondered what was to be done. There were no more single-connection lubricators on hand, and to make a double connection would mean an expensive shutdown. It would not do to run the engine without cylinder oil, and so I decided to try a makeshift.



LUBRICATOR CONNECTION

I found an old double-connection lubricator and connected it to a ½-in. tee as shown in the sketch. The side connection of the lubricator was screwed into one end of the tee so that the side opening came on top, and a valve was connected to this opening.

A piece of ⅜-in. brass pipe was bent in the form of a loop to connect the valve and top connection of the lubricator, making the top of the loop about 12 in. above the top of the lubricator so as to give a good hydrostatic head. A short nipple was screwed into the other end of the tee to connect it to the steam pipe. The sketch will make all connections clear.

On testing for tightness of joints, I found "an improvised single-connection lubricator." It was only the work of a moment to shut the steam off from the branch pipe to the engine, unscrew the old lubricator and put the improvised one in its place and start up again. The shutdown was not over two minutes, and no damage was done.

The lubricator worked so satisfactorily that it has never been changed, and it certainly has some advantages over the old way. J. R. Chapman.

Fairfield, Maine.

Coal Required by Power Plants

The coal consumption of any power plant governs, in large part, the economy with which power is being produced. This is as true in the case of a small plant with old, obsolete and wasteful engines as it is in the most efficient modern plant with its economical and highly efficient steam turbines, high-speed condensing engines, etc., or in the plant operating on producer gas. One and all are interested in husbanding the coal pile. The bunker capacity within the power house and the storage capacity without depend upon the rate of fuel consumption, for satisfactory operation is possible only when the supply of coal is adequate and properly rendered.

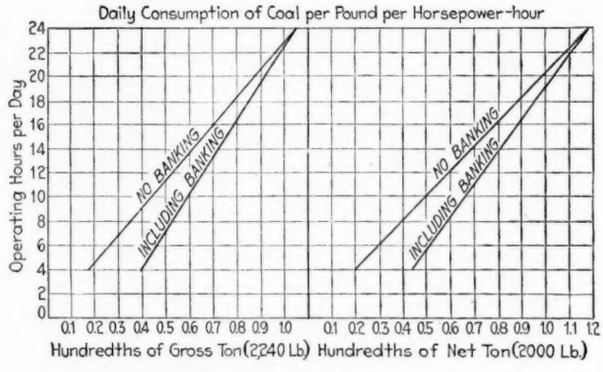


CHART FOR DETERMINING COAL REQUIRED FOR STEAM PLANT

The amount of coal to purchase, store, etc., both for normal operation and suitable reserve or emergency requirements presents no very intricate calculations, but they are rather laborious and have to be frequently repeated. To the management and the accounting department such repetition is more or less a burden that does not tend toward efficiency or economy. With quite a sufficient degree of accuracy these calculations can be much more rapidly made with the assistance of charts such as shown herewith.

Take a 1,000-hp. plant, for instance, operating 10 hr. per day for 256 days per year, 6 hr. per day on Saturdays and shut down on Sundays and holidays—during week days the fires to be banked over night but to be drawn over Sundays and holidays—consuming 2¼ lb. of coal per horsepower hour. That is, the plant is operated 10 hr. per day including banking 256 days per year, and 6 hr. per day without banking 52 days per year. The coal burned per year would then be as follows:

Hp.	Days	Rate	Chart Reading	Tons
1,000	× 256 ×	2.25 ×	0.00590 =	3,398.40
1,000	× 52 ×	2.25 ×	0.00263 =	307.71
			Total coal burned per year...	3,706.11

Say, 3,750 gross tons per year.

New York, N. Y. Reginald Trautschold.

Principles and Practice of Dynamic Balance*

By N. W. Akimoff†

SYNOPSIS—Dynamic balance is a part of the mechanics of engineering. The problem is capable of a definite solution if proposed in a rational manner and treated along rational lines. The author separates the problem into two parts—static and dynamic balance—and explains dynamic unbalance by the centrifugal couple. He describes his machine for creating a centrifugal couple at will, which may be adjusted by trial exactly to counteract the one that may be present in the body to be tested and permits definitely establishing the plane, sign and exact numerical value of the centrifugal couple of the body. Applications of these principles to the actual practice of balancing, together with explanation of working methods, are given in the article.

In this paper is described a machine that I devised to correct the condition of dynamic unbalance. The description is preceded by an explanation of the phenomenon of dynamic unbalance, made as elementary as possible by carefully excluding all references to products of inertia, momental ellipsoids, free and forced oscillations, etc. The subject of dynamic balance is not an involved one, and I feel it is time for it to be placed on a purely rational basis.

The balancing of reciprocating parts is purely a matter of calculations and of design; but the balancing of rotating parts, aside from the design, is a matter of trial and adjustment, because of its accidental nature. In a theoretically perfect rotating body, symmetrical and made of homogeneous material, there cannot be any question of running balance—such a condition would be understood as a matter of course. But we know that in practice nearly all bodies rotating at high speeds show a certain amount of unbalance. The immediate consequences of this unbalance are vibrations in automobiles and turbines; defective commutation in electrical machinery; undue wear and strain on bearings; defective products in the cases of grinding disks for steel balls, wood-working machinery, etc.

As is well known to all, an unbalanced condition of a rotating body may be due to two distinct causes—lack of static balance and lack of dynamic balance.

By static balance is understood the condition when the center of mass of the body lies somewhere on the axis of rotation. Such a condition is easily obtained on one of the static balancing machines of the knife-edge or of the roller type. In order to place the body into static balance, it is sufficient to drill one hole or to add one weight, although either of these might be split up into one or more components whenever desirable.

Now, by dynamic balance is understood the condition when there is no so-called centrifugal couple in any axial plane. In a statically balanced body, Fig. 1, a centrifugal couple can only be due to two masses m and n on opposite sides of the shaft and located at a certain distance c axially from each other. Such masses may be, for instance, the centers of gravity of corresponding congested regions. At any rate, in view of the static balance (1) such masses must be in some axial plane, and (2) the products of each mass and its respective distance from the axis of rotation must be equal.

Such a couple is in general numerically equal to a certain coefficient multiplied by radius times weight times axial distance—that is, equal to kmrc, where k involves the speed as well as other numerical constants. Now we shall choose the unit of speed in such a manner that k can be made equal to unity, so that the centrifugal couple is equal to mrc or nRc (since mr = nR).

Since the effect of a couple can only be counteracted by that of another couple, it will be seen that any effort to balance such a body as in Fig. 1 by adding one weight or drilling one hole cannot fail to make matters worse. Such a method not only does not take care of the centrifugal couple, but also distorts the static balance.

It seems to be a "natural feeling" that the way to correct unbalance is to drill a hole at the "high spot"—the point where the marking tool touches the body. Indeed, it appears that various devices have been designed and are now on the market precisely for marking such "high spots," after which judicious removal of metal is supposed to secure the desired condition of balance. These devices are based upon the so-called floating-bearing principle Fig. 2

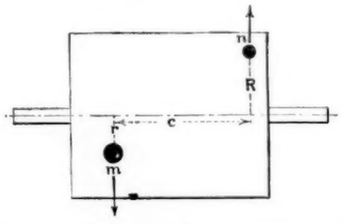


FIG. 1. CENTRIFUGAL COUPLE IN STATICALLY BALANCED BODY

FIG. 2. FLOATING-BEARING PRINCIPLE

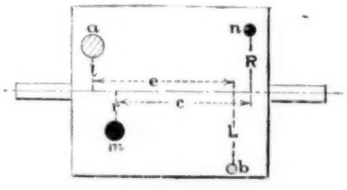


FIG. 3. COUPLE COUNTERACTING CENTRIFUGAL COUPLE

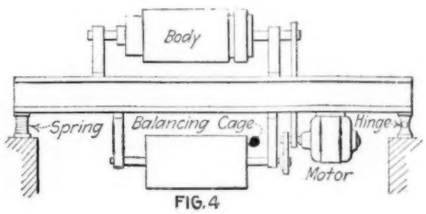
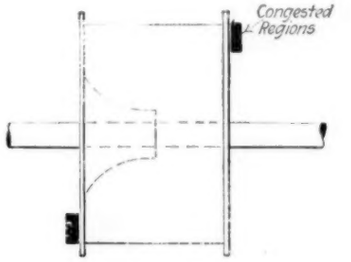


FIG. 4



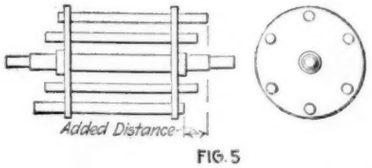


FIG. 5

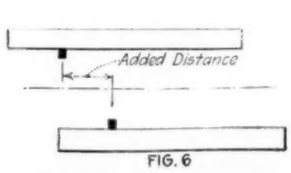


FIG. 6

FIGS. 4 TO 6. PRINCIPLES AND CONSTRUCTION OF DYNAMIC BALANCING MACHINE AND SETTING OF BARS FOR AN UNBALANCED FAN

Fig. 4—Principle of dynamic balancing machine. Fig. 5—Construction of squirrel cage. Fig. 6—Dynamic unbalance in special fan

*Presented at the spring meeting, New Orleans, La., April, 1916, of the American Society of Mechanical Engineers.

†Engineer, Dynamic Balancing Machine Co.

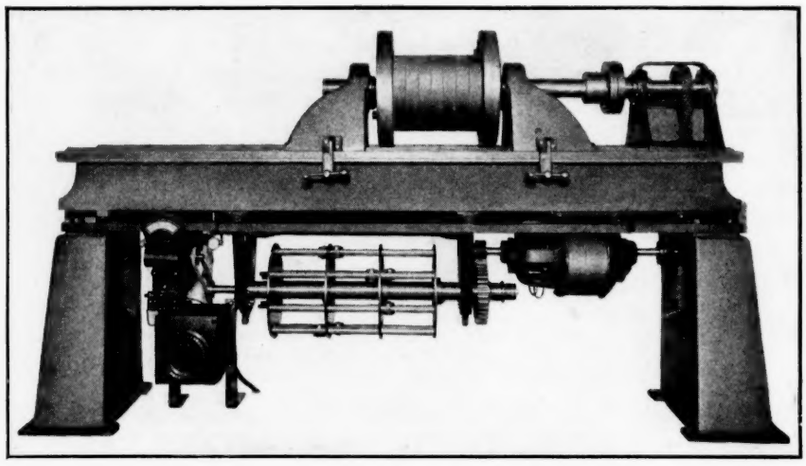


FIG. 7. AKIMOFF'S DYNAMIC BALANCING MACHINE

—that is, are provided with bearings yielding in the horizontal plane to emphasize the running of the body out of true. Of course all such devices can only serve to indicate that the body is out of balance; they can give neither the true axial plane of the disturbing centrifugal couple nor the numerical value of it. Also, drilling in any one place, as has just been seen, cannot secure dynamic balance, but can only distort the static balance.

It appears likewise that an attempt has been made to balance disks, wheels, pulleys, etc., by pivoting them on one point and by marking the "high side." It is extremely difficult to ascertain just what is the underlying idea of such apparatus, as rotation of bodies on a fixed axis and rotation about a fixed point are two entirely separate chapters of dynamics, the latter much more difficult than the former; and the deductions of one apply in no way to the other. The same remark applies to the method consisting of rotating a body suspended on a flexible shaft (wire rope) and observing the high spots in this manner. All such attempts to ascertain the dynamic unbalance are perfectly irrational.

What it is absolutely necessary to know in a statically balanced body is: (a) The exact location of the axial plane of the disturbing centrifugal couple; (b) the exact numerical value of the disturbing couple; (c) the sign of the couple—that is, the direction of the vector representing the couple. Indeed, with the axial plane of the disturbing couple known, attention can be limited to that plane; and what is done on one side of the shaft will be repeated on the other side so as to preserve the static balance. Furthermore, with the numerical value of the couple mrc, Fig. 3, known, all that has to be done to secure dynamic balance is to introduce an opposing couple ale of the same magnitude. Of course, this counteracting couple can be introduced in a variety of ways, small holes drilled on a large radius and far apart axially being equivalent to larger holes located on smaller radii and nearer to each other axially.

It will be seen from the foregoing that a machine to deserve the name of dynamic balancing machine absolutely must indicate the plane of unbalance as well as the numerical value and sign of the unbalancing couple. I claim to have produced such a machine, of which the following is a brief description:

A rigid horizontal beam, such as a lathe bed, Fig. 4, is hinged at one end and supported by a spring at the other. The body to be tested, already in perfect static balance, is rotatably supported on the beam. If dynamically unbalanced, the body will, when rotated, cause the beam to vibrate in a vertical plane, with a period of oscillation equal to the period of rotation of the body. In other words, if the speed of the unbalanced body is, say, 315 r.p.m., the beam will vibrate at the rate of 315 complete oscillations per minute, quite regardless of the characteristics of the spring (except possibly at the very beginning of motion). Now imagine a second body, exactly similar in every respect to the first, also in perfect static balance, but dynamically unbalanced to precisely the same extent as the first body, temporarily associated with the same beam, say suspended under it. If these two bodies are oppositely located as to balance and run precisely at the same speed (synchronously), then the unbalancing or disturbing couples will cancel out and the beam will have no tendency to vibrate, no matter how badly unbalanced individually are the two bodies. This is the fundamental principle of the machine—to determine unbalance by determining the unbalance necessary to neutralize its effect. In the actual machine, instead of the second body being an exact image of the original unbalanced body, it is a so-called squirrel cage, and this is rotated in unison with the article to be tested. The cage, Fig. 5, consists of two or more circular disks, carrying an even number of rods (usually six or eight) arranged slidably in the disks. The rods are accurately made, and their common weight is known; therefore, any displacement of one of the rods with respect to the one exactly opposite will not affect the static balance, originally perfect, of the cage, but will introduce a certain centrifugal couple, according to the relative displacement.

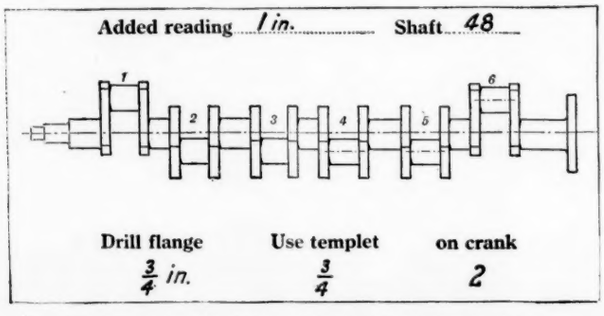


FIG. 8. DIRECTIONS FOR BALANCING SHAFT

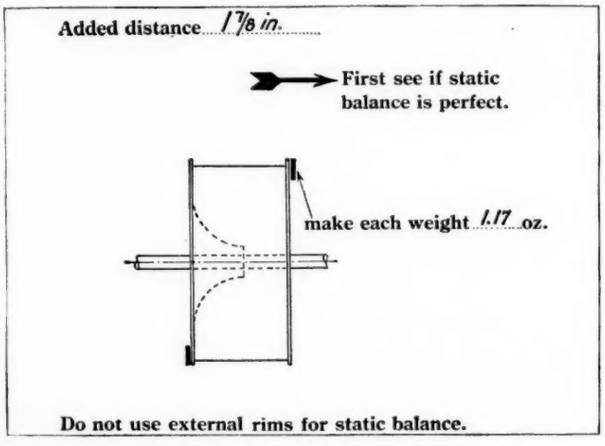

Added distance 1 7/8 in.
First see if static balance is perfect.
make each weight 1.17 oz.
Do not use external rims for static balance.

FIG. 9. DIRECTIONS FOR BALANCING BLOWER

For instance, suppose that the unbalanced body is a special fan, Fig. 6, and that the unbalance is due to two excess weights, grossly exaggerated in the figure. This will result in a centrifugal couple; and to counteract it, the cage will have to be put into a state of unbalance, as shown by the relative displacement of the rods and as measured by the added distance.

Thus the cage has means for indicating the exact amount of unbalance which has been put into it in order to reproduce with the opposite sign the exact unbalance of the article being tested. For instance, the displacement or added distance of $\frac{15}{16}$ in. may represent (for a certain speed) a couple of, say, 120 oz.-in. The plane of unbalance is easily established by the location of the two rods, the moving of which into a new position stops the vibrations; and the value of the couple is immediately given by the added distance.

It should be clearly understood that the centrifugal couple due to the body acts upon the beam in a simple harmonic manner—that is, according to the law of sines—but so does the effect of the balancing cage. In other words, when the axial plane of unbalance is vertical, the effect of unbalance on the hinged beam is the greatest, as also is the effect of the correcting element, the cage.

When the plane of unbalance is horizontal, that of the correcting element is likewise horizontal, since the cage and the body rotate in unison and neither is in any manner felt by the beam, which does not respond visibly to any

but vertical efforts or the vertical components of other couples.

So far as the spring, Fig. 4, is concerned, its object is to intensify the amplitude of the vibrations, although an unbalanced body will always cause the whole bed to vibrate with a frequency corresponding to the speed of the body (on this principle is based the well-known vibrating tachometer).

However, there is an additional advantage in the use of the spring, as it is always possible to select the characteristics of this so that, under its load, its free period of oscillation will correspond exactly to the rate at which it is desired to run the test. Such a synchronism has a large magnifying effect, so that even a slight unbalance results in a considerable amplitude of oscillation. The natural period of oscillation of the spring is calculated from

$$T = 2\pi \sqrt{MUd}$$

where

T = Period in seconds of one complete (double) oscillation;
M = Mass by which the spring is actually loaded;
Ud = Unit deflection, feet per pound of load;
$\pi = 3.1416$.

The details of construction of the cage would not be of any material interest in the present discussion, but the main feature is that the rods can be adjusted axially while the

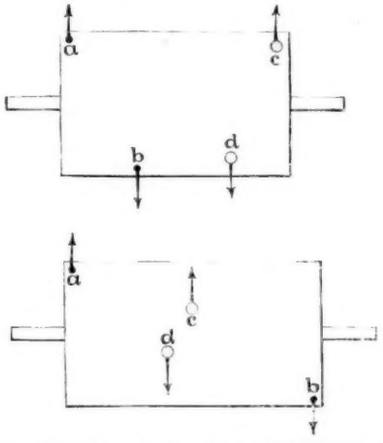


FIG. 10. SPECIAL CASES OF CORRECTING COUPLE

cage is in rotation, the speed of the cage never being higher than 400 r.p.m. or so.

With regard to the proper speed at which to balance a body, I submit the following considerations: Unless the body itself is elastic or is mounted on a flimsy shaft, the body balanced at any speed will run true at any other speed. If the shaft is not strong enough, no balancing machine can make it stronger. If the windings of a rotor seek to find their places under a certain speed and temperature, they should be allowed to do so, after which balancing can be done. In the high-spot method, in which azimuth (commonly known as lag or lead) depends upon the speed itself, it is of course of considerable importance to watch the speed; but in the rational method here proposed the best speed is determined only by the characteristics of the spring, Fig. 4.

Fig. 7 illustrates a type of machine for testing automobile crankshafts previously placed in perfect static balance. The information furnished by the machine is simply the relative displacement (added distance) of one of the pairs of rods of the squirrel cage. By referring to a set of specially prepared dimensions, similar to those shown in Fig. 8, the operator can pick out readily the necessary directions as to how to remove a certain amount of metal from one of the cranks and how to drill the flange in order to secure perfect dynamic balance.

A similar machine is for balancing special blowers. If all such fans are of the same size, the directions will be given in the very easy form shown in Fig. 9. There can be no ambiguity in carrying out the instructions.

It is not necessary to dwell on the extreme importance of testing a body for unbalance in its natural position and upon its own bearings. This machine in its very conception is adapted for testing under such conditions.

The importance of static balance cannot be over-estimated. Fortunately, such a condition can be readily secured. Theoretically, one pair of rods in the squirrel cage, Fig. 5, of the machine would suffice, since the relative position of the rods to the body being tested can be altered readily through the transmission (chain drive shown in Fig. 4). For convenience, however, it is best to have three or four pairs of rods, and even then it is sometimes necessary to change the angular position of the cage so that the balancing can be done by one pair of rods and not two, at the beginning of a test.

Fig. 10 illustrates a somewhat special case. Here the correcting couple cd, numerically equal to the disturbing couple ab, has been introduced for some local reason in the manner shown; that is, the action of the correcting couple seems to be in a region rather remote from that of the disturbing couple. This simply means that the two actions will neutralive through (and within) the body. Even in such an extreme case, however, the supports or foundations of such an apparatus will be found to experience no vibratory effect.

A 35,000-kw. Turbine for the Boston Elevated

A 35,000-kw. single-casing General Electric turbine will be installed in the South Boston Station of the Boston Elevated Railways Co., by Dec. 1, 1916, if the present plans carry. The unit will be 45 ft. 6 in. long, 20 ft. wide and 12 ft. 3 in. high over all. The speed will be 1,500 r.p.m., the pressure 200 lb., with 200 deg. superheat, total temperature 588 deg. F. at the throttle. The machine will have a maximum capacity for 2 hr. of 42,500 kw. Should it be compelled to run noncondensing, it will be able to exhaust against an absolute back pressure of 18 lb. and deliver 15,000 kw.

The guarantees are rather interesting in that they are the lowest that have come to our attention. At 200 lb. (gage), 200 deg. superheat, 1,500 r.p.m. and 1-in. back pressure, 10,000 kw., the steam consumption is 12.10 lb. per kw.-hr.; 15,000 kw., 11.30 lb.; 20,000 kw., 10.85 lb.; 25,000 kw., 10.65 lb.; 35,000 kw., 10.95 lb.

A generator of the two-pole type will be used, delivering 25-cycle current at 13,200 volts, three-phase. The unit will weigh about 860,000 lb.

Relative to the guarantee, the low steam consumption of 10.65 gives a Rankine cycle efficiency ratio of 63.44 per cent., which is not unusual, considering that tests of a 30,000 kw. cross-compound machine reported by H. G. Stott before a recent meeting of the New York section of the American Society of Mechanical Engineers, showed Rankine cycle efficiency ratios of 72.5 to 75.8 per cent.

Concord to Retain Its Municipal Plant

An interesting report in favor of retaining the existing municipal plant at Concord, Mass., has just been made public by an investigating committee charged with the task of considering the advisability of purchasing electricity from the Edison Electric Illuminating Co. of Boston or of any other company. It had been proposed to sell current to the town on a wholesale basis only, the distribution of energy being continued by the municipal lighting department. The Lowell Electric Light Corporation, the New England Power Co. and the Marlboro Electric Co. were also asked for bids, but as the first two were not interested and as the last proposed to supply electricity over a wooden-pole line, and as its rates were higher than those of the Boston company, the latter's bid was the only one requiring extended study.

The Boston company offered to supply energy at the switchboard on a 20-yr. contract at a price, based on present consumption, of 1.84c. per kw.-hr. As part of the transaction it was to buy at a price of $10,000 the present steam-generating station at Concord, which has a capacity of about 1,000 kw. in turbo-generators and about 500 kw. in engine-driven stand-by units. The committee found that over a 20-yr. period a saving of probably over $2,000 per year would accrue by using Edison service, but that the larger part of the saving would come toward the end of the contract because the Edison company's charge would automatically become lower with a larger consumption and a better load factor, as might be expected with the growth of the town. Attention was called to the various fixed schedules of the company based upon the amount and kind of service desired, and the point was made that a contract could undoubtedly be made as advantageously later as now, with the added consideration that by delaying, more data might be secured which might prove or disprove present conclusions.

If the municipal plant had faced a situation requiring immediately a large amount of capital for extensions and improvements, this would have had further bearing on the problem, for in that case it would clearly be unwise to

make material expenditures if the committee were convinced that the cost of local manufacture is greater than by the use of purchased power. Incidentally, a local mill at Westvale, whose early inquiry for a considerable block of power brought the whole subject to a head, has now decided that it does not wish to purchase outside current. It was recognized that acceptance of the Edison offer would protect the town against such contingencies as higher prices of coal (coal representing over half the manufacturing cost in the present plant), laws regarding shorter hours of labor for municipal employees, increased cost of supplies and the application of the pension system. But these advantages, including the estimated saving in operation, were insufficient in the committee's opinion, to justify the change.

National Electric Light Convention at Chicago

With an attendance of 3,350 and a program covering over sixty committee reports, twenty-two papers and numerous addresses, the National Electric Light Association held its thirty-ninth convention in Chicago from May 22 to 26, inclusive. Headquarters were at the Auditorium and Congress Hotels, and the display of electrical appliances was shown at the Auditorium Theater. Two special trains brought members from New York and intermediate points and another from St. Louis.

Following registration and a reception to members and guests at the Congress Hotel on Monday evening, the opening session was on Tuesday morning with an address of welcome by Mayor Thompson. Commenting briefly upon the great progress made in the electrical industry since the inception of the association in Chicago in 1885, he seized the opportunity to launch into a political speech, taking up some of the economic problems now confronting the nation and expressing an opinion upon the qualifications of certain political candidates and issues.

President Lloyd followed with an address in which he reviewed the work of the association during the past year and outlined plans for broadening its scope for the coming year. He referred particularly to the proposed formation of a separate manufacturers' section, more comprehensive investigations by the Public Policy Committee, and the recent addition of the Electric Vehicle Association as a section. He also pointed out that the association has outgrown its name, which had been chosen at a time when electric lighting formed practically the entire service of the central station, and suggested that it might be changed to "National Electrical Supply Association" or to "National Electrical Association," either of which would be broad enough to cover the entire field. In reporting for the committee on organization of the industry, Mr. Sewell gave the present membership as approximately 15,000, showing an increase of about 1,500 during the past year.

PROGRESS OF THE INDUSTRY

Secretary Martin's report on progress was full of useful and interesting data presented in his characteristically entertaining style. Owing to its great length it was read only in part, however. Reviewing the general conditions of the industry with special reference to the present abnormal state of affairs, he gave a very optimistic outlook, although the present demand on capital and the difficulty of getting deliveries on material have somewhat handicapped the central station in keeping pace with the demands. Reference was made to some of the exigencies with which the industry is confronted in the countries at war and the means being taken to meet them. Other sections of the report dealt with steam-generation plants (hydro-electric plants being dealt with separately in Part II), lighting, electric furnaces, industrial heating, domestic electrical heating, domestic electrical appliances, the electric vehicle and industrial motor applications.

The remainder of the morning was taken up with the reports of the committees on Relations with Educational Institutions and on Company Sections and that of the insurance expert. Past-President Weeks also proposed that the association, in conjunction with the American Institute of Electrical Engineers and the Franklin Institute, establish a fund to be known as the "Professor Elihu Thomson Scholarship Fund," the interest on which would be used to defray the expenses of some student of applied electricity in one of the American universities.

On Tuesday afternoon simultaneous sessions were held by the Technical and Hydro-electric, the Accounting and the Commercial sections. The first was opened with an address by its chairman, H. H. Scott, who referred to the recent expression of the executive committee that all reports in the future should not be adopted till one year after presentation and then only as recommended rules. He called attention to the joint conferences with the Bureau of Standards relative to the Electrical Safety Code and expressed the belief that the bureau would not intentionally provide rules that would work hardships on central stations.

The report of the Committee on Meters was read in abstract by C. G. Durfee, and covered briefly an investigation of instrument transformers with a view to standardization and methods of testing them. Recent developments in meters and other instruments were illustrated and an addendum to the "Electrical Meterman's Handbook" included, to bring the latter up to date.

Important in the recommendations of the Committee on Electrical Measurements, Values and Terminology was the suggestion that all publications of the association and references thereto have the English units of measure followed by the metric equivalents in parentheses. This report also attempted to prescribe a list of abbreviations for technical terms with the suggestion that it be followed by the leading engineering societies and technical publications. The arbitrary fixing of these terms and a number of glaring inconsistencies led M. G. Lloyd to protest, with the result that the report was referred back to the committee.

LIGHTNING PROTECTION FOR TRANSFORMERS

A paper on "Lightning Protection for Transformers on 4,000-volt Distribution Circuits" was next read by D. W. Roper. This gave the result of an investigation made to find the causes of interruptions due to lightning on a 60-cycle distribution system in Chicago. As a result of this investigation the following changes were made:

1. Transformers were purchased without primary terminal boards.

2. Terminal boards were removed from all transformers installed as fast as possible.

3. All lightning arresters were moved from line poles to the transformer poles, and additional arresters were installed on transformer poles.

As a result, burn-outs due to lightning have been reduced from about 1.2 per cent. to 0.25 per cent. and the transformer fuses blown by lightning have been reduced from 15 per cent. to 1.2 per cent. per year.

This year it was decided to hold the discussions on Public Policy in executive session, open only to official representatives of the member companies. This took place on Tuesday evening

On Wednesday morning were held the second accounting, second commercial and third general and executive sessions. Of special interest at the last-named meeting was the report of the Rate Research Committee, which was presented by Alex. Dow, of Detroit. It discussed the value of a minimum charge in rate-making for residential service and properly controlled flat rates; rates for farm service with particular reference to payments for line extensions; and finally criticized the three-cent rate of the Cleveland municipal plant as defective. A weekly magazine called "Rate Research" is now being published by this committee.

At the second technical and hydro-electric session on Wednesday afternoon, E. B. Meyer presented the report of the Committee on Underground Construction. This went very exhaustively into the latest practices as concerns manhole switches of various capacities for potentials up to 10,000 volts, new types of cable joints, instruments for testing cables, moisture in cables and various means that have been tried out for cooling duct lines and thus reducing the danger of burn-outs from overheated underground cables.

Secretary Martin then read in abstract the second part of the Progress Report, devoted to hydro-electric construction and transmission. He reviewed the work of a number of water-power conferences that have been held during the past year, commented upon the water-power report recently compiled by the Government and urged the passage of the Shields bill now pending before Congress. He described briefly some new developments now in process of construction or recently completed, including two new power houses of the Pacific Gas and Electric Co.; the plants of the Montana Power Co.

for supplying the electrified section of the Chicago, Milwaukee & St. Paul R.R., which will take in about 450 miles; and new work of the Central Power Co. in the Yosemite National Park, which matter is now under advisement by the Secretary of the Interior. The report concluded with a review of some foreign hydro-electric projects and developments.

Following Mr. Martin's report H. J. Pierce, of Seattle, who has been representing water-power interests at Washington for some time, delivered a lecture on water-power legislation He reviewed the need for water-power development in the various industries and sections of the country and strongly advocated the passage of the Shields and the Meyers bills, now pending in Congress.

The report of the Committee on Overhead Lines and Inductive Interference was devoted largely to the National Electrical Safety Code, which was considered for final discussion at a conference with the Bureau of Standards in Chicago, May 29 and 30. The code, while undoubtedly tending to eliminate improper construction, embodies in its present tentative form, material increases over present practice, and its possible influence in increasing construction costs is viewed with apprehension by the committee. Public regulation of line construction was also dealt with to some length by the report. The discussion that followed emphasized the fact that the code would undoubtedly be adopted by the various public service commissions, that it would be very difficult to follow strictly some of the rules regarding construction now embodied in it and that therefore heavy damages would be likely to follow any accidents.

In the commercial sessions a few papers of interest to "Power" readers were presented. C. J. Carlsen, of the Commonwealth Edison Co., abstracted a voluminous report dealing with central-station service in the manufacture of artificial ice, and particularly raw-water ice, in the making of which motors may be used to advantage. Statistics and test data comparing steam and oil engines with the motor, operating data on the varied equipment making up a refrigerating system, plant records and other features of interest were included. The speaker gave special emphasis to the character of the load and the great opportunities for the central station in this branch of the industry, which, according to the census reports for 1914, yielded a product valued at 62 million dollars.

The principal entertainment feature was given on Wednesday evening in the form of a big frolic at the Bismark Garden.

REPORT OF ACCIDENT PREVENTION

At the third technical and hydro-electric session, on Thursday morning, Martin J. Insull read the report of the Committee on Accident Prevention. Passing briefly over the economic loss as a result of accidents, Mr. Insull pointed out that investigation of a large number of cases of avoidable accidents has shown approximately 15 per cent. to have been due to mechanical conditions and 85 per cent. to the "human element." He had found that, although a number of the larger companies have given serious consideration to accident prevention, there appears to be a surprising indifference on the part of most member companies to this work. Where such attention has been given, the results have more than justified the efforts. The report concluded with suggestions to the employer on how to proceed with such work and included illustrations of a number of effective safety appliances.

The Prime Movers report presented in abstract by the chairman, I. E. Moultrop, covered 179 pages and dealt with practically all pieces of power-house equipment as well as latest practice in their operation. It included a resolution calling upon the American Society of Mechanical Engineers to recommend a method of rating boilers that will be logical and usable and replace the present irrational method. The report will be abstracted in part in a later issue.

The report of the Committee on Electrical Apparatus contained a résumé of the year's developments in the construction of generating and converting apparatus as well as lightning arresters and switchboard equipment. Considerable space was given to recommendations covering the standardization of sizes, voltages and taps for transformers; and moreover, the use of the new A. I. E. E. Standardization Rules when specifying new apparatus was strongly urged, especially as regards capacity ratings and permissible temperature rise.

In an illustrated lecture W. A. Durgin showed how lighting might remain the biggest factor in central-station business instead of dwindling into a byproduct of the power end. In ten years the lighting load of the Commonwealth Edison Co. had decreased from 70 to 20 per cent. of the total output, notwithstanding that the lighting load was continually on the increase. The taking over of a great railway load partly explained the situation. Although in 1915 the lighting demand was 21 per cent. of the entire output, it was responsible for 50 per cent. of the gross receipts. It brought in as much revenue as the power and railway loads combined and evidently was a good business to foster. To offset the decreased current consumption due to more efficient lamps and to maintain lighting as the major producer, there were three courses—higher intensities, semi- and indirect lighting and the application of color schemes for display rooms and in the home. People must be educated to the use of more light. The average 2½-ft. candles now in common use should be increased to 8 or 10, and even then only one-third of the intensity of daylight, 25-ft. candles would be obtained. If concentrated, the lighting must be indirect or amber globes be used to protect the eyes. Either increased the amount of energy required and coupled with more liberal lighting would boost the load by a large percentage. A demonstration showing the effect of different light intensities and the use of colored globes in the home and in the display room was received with great interest.

RAILWAY ELECTRIFICATION LOADS

On Thursday afternoon, at the fourth and last technical and hydro-electric session, the principal topic was railway electrification as related to central-station load. This was covered by two papers—one the report of the Committee on Power Supply for the Electrification of Steam Railroads (read by Peter Junkersfeld), and the second by F. Darlington, on "Central Station Electric Systems and Railroad Power." The former reviewed what has been accomplished in the supply of purchased electrical energy for railway purposes, set forth economic reasons why central power companies should supply power for railway purposes and recommended that member companies in planning for the future consider the possibility of supplying such loads.

Mr. Darlington strongly urged increased centralization of power, maintaining that the cost of producing power is a heavy tax upon industry that can be greatly reduced by drawing more on central-station systems and depending less on isolated plants. To illustrate his contentions, he referred particularly to the conditions in central Connecticut, where there are a number of cities having central power plants of 1,500 to 5,000-kw. capacity. If unified service were provided for this part of the state, a large power plant could be constructed where coal and condensing water are easily obtainable, as on Long Island Sound; large, highly economical turbines could be used and power transmitted over a continuous-loop circuit connecting the cities.

The two papers were discussed jointly by Samuel Insull, of Chicago, who dealt with the economy of bringing the smaller central plants into a unified system, saying that it was not essential that the capitalization be thus combined, but that it was vital that the operation of the plants be under a single control. As an illustration he mentioned that it is often difficult for a central station in a small town to acquire the business of a large manufacturer owing to inability to insure entirely satisfactory service, whereas, if the central station is tied in with a larger system, these objections have no weight. Mr. Insull seemed to place more importance on getting the business of manufacturers and isolated plants than railway load. The question of electrification of steam roads he believed to be purely a matter for the railway man to decide, and believed that the central stations should merely stand by ready to serve when the time comes.

Another speaker brought out the interesting fact that where a street railway buys power from a central station the latter is little affected by fluctuations in traffic, provided the service is maintained. This is because of the relatively small ratio of the live load (passengers) to the total load of the car.

Commenting on the electrification of the Chicago, Milwaukee & St. Paul, J. B. Fisken said that 30 to 35 per cent. of the power required on the steep mountain grades is returned to the system by regenerative braking, in going down the mountains.

The report of the Committee on Street Lighting was read by Mr. Millar, after which the new chairman of the Technical and Hydro-electric section, R. J. McClelland, was introduced.

COMPETITIVE POWER SOURCES

At the fifth commercial session the Committee on Competitive Power Sources, E. F. Tweedy, chairman, presented a report dealing with the characteristics of the newer types of prime mover such as the Diesel and semi-Diesel oil engines, the gas engine operated with producer gas, the locomobile steam unit and the uniflow and poppet-valve steam engines. Data on installations and operating costs were

given, and as competitors to the central station the disadvantages of the various engines were brought to the fore. Although the operating cost of the Diesel engine is low, the initial cost and consequently the fixed charges are excessive. Their inability to carry overload is another disadvantage.

The uniflow and poppet-valve engines are also high in price, and their operation in practice is not so successful as the guarantees would imply. A commercial test on the locomobile was cited showing that the coal consumption was double that given by the builder. The unit was noisy in operation, required almost continuous firing, owing to the small firebox, and it ran excessively hot, necessitating constant watching and the use of a large amount of oil. The success of the producer plant depends absolutely upon skillful operation. As skilled operators are scarce and high-priced, it is seldom that the right kind of men are obtained, so that the gas plant has gained a reputation for unreliability. The cost of a shutdown in factories, even for a short time, is costly, and owners prefer comparative security from breakdown even at some slight increase in the cost of power. An appendix gave the rules and requirements of the National Board of Fire Underwriters for the storage and use of fuel oil.

On Friday, the last day of the convention, final meetings were held by the commercial, company and general sessions. Award of the Doherty medal went to B. H. Blaisdell, of Manila, P. I., for a paper on "Power Plant Departments"; the Williams prize of $50 went to G. A. Leibman, of Brooklyn; and the Frasse prize of $25 to George R. Jones, the last being for a paper on the "Utilization of Waste Material."

This was followed by reports of the committees on Constitutional Amendments, on the President's Address, on Memorials and on Resolutions, the last thanking the various interests that had helped to make the convention a success. Henry L. Doherty, of New York, called attention to the present agitation to illuminate with flood lighting the Statue of Liberty in New York Harbor. Sanction has been given by the Pilots' Association and the War Department, so that consummation of the project seems assured. In Mr. Doherty's opinion this would be followed by the illumination of numerous statues in cities throughout the country.

Arthur Williams, of the New York Edison Co., in commenting upon Mr. Doherty's remarks, objected strenuously to the association indorsing any project that would make use of a private plant. He believed the proposition should be carried out only on condition that service be supplied by one of the neighboring public-utilities companies through a submarine cable, although Bedloe Island, upon which the statue stands, now has its private plant supplying the garrison and the statue.

The report of the nominating committee was next received and accepted, the officers for the coming year being: President, H. A. Wagner, of Baltimore; vice-presidents, W. F. Wells of Brooklyn, R. H. Ballard of Los Angeles, R. S. Orr of Pittsburgh, and Alex. Dow of Detroit. W. A. Atkins was reëlected treasurer and the present secretary and his assistants hold over.

The new president, who is now head of the Consolidated Gas, Electric Light and Power Co. of Baltimore, is probably best known to the industry as the organizer of the Wagner Electric Manufacturing Co., of St. Louis, although at present having no connection with that company. He is a graduate of Stevens Institute of Technology, was long connected with the Westinghouse Electric Co. and was associated with one of the first large alternating-current systems in the West.

Following a brief address by Mr. Wagner, the convention adjourned.

Engineers Industrial Census

Interest is centering about the movement for the industrial census of the country, which is shortly to be undertaken by 30,000 American engineers and chemists constituting the membership of the four national engineering societies—the mechanical, civil, electrical and mining engineers—and the American Chemical Society. These five organizations have pledged their services to the government of the United States, and their members will give their expert services as a patriotic duty, in appraising the industrial and natural resources of the country.

The movement had its inception when Secretary Daniels of the United States Navy invited the American Society of Mechanical Engineers and ten other organizations to form the United States Naval Consulting Board, to be headed by Thomas A. Edison. This board resolved itself into committees, one of which, the committee on production, has as its chairman Howard E. Coffin, who formulated a plan for organizing the industries of the country for preparedness. This led the President of the United States to invite the five organizations mentioned to nominate a representative in each state to assist the Naval Consulting Board in "collecting data for use in organizing the resources of the country." In each state, therefore, there is this committee of five, which will act as "Direction of Preparedness" in its own state. The members of the five societies become automatically "Field Agents" under the directors.

The headquarters for the industrial census has been provided jointly by the mechanical, electrical and mining engineers societies in the Engineering Societies Building, 29 West Thirty-ninth St., New York, where the clerical force has been temporarily arranged for through subscriptions from engineers. As soon as Congress legalizes the Naval Consulting Board, however, which it is expected it will do very shortly, President Wilson will be authorized to provide an adequate Government staff.

It is estimated that there are in the country 30,000 manufacturing plants that could supply munitions of war, by which is meant not only arms, shells and powder, but supplies of all kinds. In other words, there is one plant for each member of the five societies, so that it will be possible to carry out the census expeditiously through the intelligent service of trained experts.

Blanks have been prepared upon which the information is to be tabulated. Lists of manufacturers are available in the census department of the Government, and the committee in each state will call upon the various society members to visit certain definitely specified plants to secure information upon their facilities for supplying munitions and needed articles.

Within a month a million-dollar advertising campaign is to be started, arranged through the Associated Advertisers Club of the World, with the coöperation of leading magazines and daily papers, which have contributed space. The advertisements will draw the attention of the public to the fact that armies, navies, guns and men are futile so long as the factories that turn out the supplies are not prepared. The work that engineers are able to do and will do in organizing the industries will be featured, and the fact that three men are required in the factory for every man at the front impressed upon the reader. The slogan of the movement will be "What Engineers are doing for National Defense and International Peace."

National District Heating Association Convention

The eighth annual convention of the National District Heating Association met in New York City, May 16 to 19 inclusive. A number of valuable papers were presented, some of which will be published in "Power" as space permits, either in abstract or in their entirety. During the first session Borough President Marks delivered an address of welcome, which was responded to by Byron T. Gifford, of Grand Rapids, Mich. and President Davis S. Boyden delivered his address. After this routine business was transacted the report of the public policy committee by D L. Gaskill and the report of the educational committee by George W. Martin were presented.

At the afternoon session two papers were presented—one by S. Morgan Bushnell, on "Factors in the Growth of District Heating," and the report of the Station Operating Committee by its chairman, Byron T. Gifford.

At the opening session Wednesday morning an address was given by Arthur Williams, of New York, on "District Heating and Its Relation to Electric Utility Operation." During this session the following officers were elected by acclamation for the ensuing year: President, Byron T. Gifford, Grand Rapids, Mich.; vice-presidents George W. Martin, New York, J. H. Hecht, Chicago, Ill., and J. C. Hobbs, Pittsburgh, Penn.; secretary and treasurer, D. L. Gaskill, Greenville, Ohio; and members of the executive committee, C. A. Gillman, New York, and A. E. Bettis, Kansas City. No session was held in the afternoon, the entire delegation indulging in a boat ride around the Island of Manhattan.

At the fourth session on Thursday morning a paper by William J. Baldwin, chief engineer of the New York Steam Co., on "Coöperating with the Consumer"; an address on "Appraisals of Utility Property," by M. F. Millikan, read in his absence by Secretary Gaskill, and the report of the rate committee by A. E. Bettis, its chairman, were the features.

During the afternoon session on Thursday the report of the publication and editorial committee and also that of the record committee by A. P. Biggs, chairman, were read and two papers—"Ratio of Economizing coils of the Different Types of Heating Systems," by W. J. Kline, and another by E. G. Bailey, on "Methods by Which Harvard University Buys Steam on a Heat-Unit Basis"—occupied the session.

At the closing session Friday morning the report of the meter committee by B. F. Orr, chairman, and the report of the delegates to the Pan-American Scientific Congress, by J. A. Donnelly, of New York and Nelson S. Thompson, of Washington, D. C., followed an address by Travis H. Whitney, public service commissioner of New York City.

The sessions throughout were attended with great interest by the delegates present. In the exhibitors' section there were a large number of booths well arranged for the display of valves, meters, underground construction, steam traps, etc., of particular interest to the steam-heating craft. The social events were well arranged, and included shopping trips, boat and automobile rides, a visit to the Metropolitan Museum of Art, entertainment at the Hippodrome and a banquet and dance at the headquarters hotel, the Martinique. The time and place for holding the next convention will be decided on and announced later.

Favors Standard Boilers

The National Association of Cotton Manufacturers adopted at its recent meeting in Boston the following resolution:

Whereas, The American Society of Mechanical Engineers having prepared a satisfactory code for the standardization of boiler construction to promote safety of human life and economy in operation, it is hereby

Resolved, That the association approves the said boiler code and recommends its adoption by states and municipalities where boiler laws are in force or may be enacted.

The association paid extended tribute to its late secretary, Doctor Woodbury, saying in a special resolution that to him more than to any other man is due the continued prosperity of the association and its value as a representative of the textile trade.

A resolution was passed adopting an 8½ per cent. standard of moisture for cotton and cotton fabrics, and the association voted thanks to all who had contributed to the success of its two days' meeting.

Test Committee of the A. S.M. E. Presents Its Report

The committee appointed by the Council of the American Society of Mechanical Engineers in 1909, to "revise the present testing codes of the society relating to boilers, pumping engines, locomotives, steam engines in general, internal-combustion engines and apparatus, and fuels therefor, and to extend these codes so as to apply to such power-generating apparatus as the present codes do not cover, including water power, bringing them into harmony with each other and with the best practice of the day," has presented its report and copies are now available. This report will without doubt determine the standard practice of American engineers in testing power-plant apparatus and recording the results of such tests. In addition to the work expended upon it by the eight eminent engineers who have signed this report, written discussion has been received from 75 specialists in different lines, and the preliminary report published in the "Journal" of November, 1912, was widely discussed, and in the light of the criticisms and suggestions then offered and since brought out by correspondents, that preliminary report has been extensively revised and now occupies, with its appendixes and index, 215 pages 6x9 in. in size. It appears in full in Vol. XXXVII of the "Transactions," 1915, and may be had in detached form at 70c. in paper and $1 cloth per copy by members, and at $1.40 in paper and $2 in cloth by nonmembers, from the office of the Society, 29 West 39th St., New York.

The report is divided into 14 parts. The first three parts, forming the first section, treat respectively of Instructions Regarding Tests in General, embracing the object of and preparation for the tests, description and directions for use of various apparatus, forms of report, etc.; Standards Relating to Capacity, Efficiency and Economy; and Rules for Sampling and Drying Coal and Ash and Sampling Steam and Gases. The second section comprises the individual codes, and consists of Parts 4 to 13 inclusive, dealing respectively with the Boiler; Reciprocating Engine; Turbine; Pumping Machinery; Compressor, Blower and Fan; Complete Steam-Power Plant; Locomotive; Gas Producer; Gas and Oil Engine; and Waterwheel Codes. The third section, Part 14, consists of 38 appendixes. A permanent committee has been appointed to interpret the rules when called upon to do so, to make such revisions as may be found desirable, and to modify the rules to meet new conditions as they may arise in the future; this new committee to hold meetings from time to time, at which all interested parties may have an opportunity to present suggestions.

ENGINEERING AFFAIRS

The American Electric Railway Association has decided to hold its 1916 convention at Atlantic City on Oct. 9 to 13.

The Ohio Society of Mechanical, Electrical and Steam Engineers will hold its next meeting in Cleveland, Ohio, on June 22 and 23, instead of June 15 and 16 as first announced.

The Blue Room Engineering Society of New York City will hold its closing monthly meeting and dinner on Thursday, June 9, at 103 West 38th St. Many of the latest topics in the engineering field will be discussed. The meetings will be resumed early in October.

Louisville to Celebrate Electrical Week—F. H. Miller, superintendent of motive power of the Louisville, Ky., Railway Company, is president of the Jovian League, of Louisville. He has announced that the Louisville Jovians will observe "America's Electrical Week" with a demonstration at the local armory and has named the committees which will have charge of the work.

Elizabeth Installs N. A. S. E. Ladies Auxiliary—State Deputy Jane McCoy of the Ladies Auxiliary to the National Association of Stationary Engineers in New Jersey instituted an auxiliary at Elizabeth, N. J., Wednesday, May 24. Twenty-four ladies signed the charter. Mrs. James Heath is president of the new auxiliary. Refreshments were served and Jack Armour of "Power" and Jim Devins of Jenkins Bros. entertained.

The National Association of Master Steam and Hot Water Fitters will hold its twenty-eighth annual convention at Atlantic City, N. J., Wednesday, June 21, to Saturday, June 24, 1916, inclusive. Headquarters and meetings will be at the new St. Charles Hotel on the Boardwalk and St. Charles Place. The National Association of Master Plumbers will hold its annual convention on June 19-22, in Atlantic City, at a hotel directly across the street from where the Master Steam Fitters will meet. This will be very convenient for those who are members of both associations.

The New York Section A. S. M. E. made an inspection trip, Saturday, May 20, to the Essex power plant of the Public Service Corporation of New Jersey, one of the latest and most interesting central stations in the vicinity of New York. The trip was arranged by the excursion committee of the section, John H. Norris, chairman, and about eighty participated. The Public Service Corporation was very gracious in its entertainment of the visitors, meeting and returning them to the cars with automobiles, providing an ample staff of competent guides to conduct them about the station and showing them all possible courtesies.

New England States N. A. S. E. Convention—An invitation is extended to all members of the association throughout New England to attend the New England States convention to be held at Fall River, Mass., Thursday and Friday, July 13 and 14. The mechanical exhibition will be held in the State Armory, the sessions of the convention will be on Friday, and the smoker at 9:30 Friday evening. The sessions of the convention and the smoker will be open to all members of the N. A. S. E. It is hoped by the officers and the local committee that a large number will visit Fall River at this time, in addition to the regular delegates.

Awarded of Elliott Cresson Medal—The Franklin Institute has awarded its Elliott Cresson Gold Medal to Dr. Robert Gans, of Pankow, near Berlin, Germany, for Permutit. Permutit is a gray-colored, flaky, pervious substance, which is prepared by fusing together, in the proper portions, alumina, silica and an alkali carbonate. This sodium-alumino-silicate is used for softening water, as it has the property of exchanging its sodium for the hardening ingredients (calcium and magnesium) in water filtered through it. When the Permutit has been exhausted of its sodium, it may be regenerated with a solution of common salt.

The American Iron and Steel Institute held its tenth general meeting at the Waldorf-Astoria Hotel, New York City, on May 26 and 27, attended by about 700 members and guests. Elbert H. Gary, president of the Institute, delivered an address, and papers were read on "Byproducts Recovered in the Manufacture of Coke," by William H. Childs; "The Electric Furnace in Steel Manufacture," by John A. Mathews; "Rail Manufacture," by John S. Unger; and "The Distribution of Materials in the Blast Furnace," by George W. Vreeland. At the dinner held on the evening of May 26 an address was delivered on "Coöperation and Efficiency in Developing Our Foreign Trade," by Hon. Edward N. Hurley and Jacob Loewenstein, engineer, American Bridge Co., delivered an illustrated address on "The Hell Gate Bridge."

Passaic, N. J., N. A. S. E. Held an "Old Home Night," Saturday, May 20, at its quarters in the Post Office building. The occasion was the celebration of the association's nineteenth birthday. F. R. Low, ex-mayor of Passaic and editor of "Power," also one of the charter members of the Passaic association, told how a few men met in the gashouse and organized. He brought out that business men about town looked with apprehension upon the association, fearing that it was one of many roads to labor disturbances. The association today enjoys the confidence and commendation of these same employers. Other speakers were William J. Reynold, past national president of the National Association of Stationary Engineers, and Charles H. Bromley, associate editor of "Power" and chairman of the New Jersey state educational committee of the N. A. S. E., who had for his subject "Progress." Entertainment was given by Billy Murray, Joe McKenna, Monroe Silver and Bob Jones, of Jenkins Bros.; Jack Armour, of "Power," and Bert Self, of the Peerless Rubber Co.—all under the direction of Frank Martin. Refreshments were served.

Bayonne, N. J., No. 7, National Association of Stationary Engineers was one of the largest, if not the largest individual association ever instituted in the history of the national organization. The state deputy, John J. Reddy, had toiled long and hard in organizing the Bayonne association, and his efforts were rewarded by a charter membership of 108 engineers, the association being instituted Saturday evening, May 6. There were present N. A. S. E. men from nearly every association in New Jersey and many from New York City. Among the speakers was Charles H. Bromley, associate editor of "Power," who outlined how the association's educational work should be carried on. William J. Reynolds spoke on the benefits to be had from the organization, and James Taylor, secretary-treasurer of the association's life and accident department, dwelt on association insurance. John J. Calahan, candidate for national vice-president, outlined part of his platform. Frank Martin, of Jenkins Bros., conducted the entertainment given by Billy Murray, Joe McKenna, Bob Jones, Monroe Silver, Bert Self and Jack Armour of "Power." Excellently selected refreshments were served. The officers of the Bayonne association are: President, George Peterson; vice-president, James Bright; financial secretary, Alexander Bjorklund; recording secretary, Joseph F. Cook; corresponding secretary, Conrad Peterson; conductor, J. Benney; doorkeeper, J. Russet.

OBITUARY

CHAUNCY J. BLAIR

Chauncy J. Blair, millionaire financier and at the time of his death vice-president of the Corn Exchange National Bank and president of the Kennicott Co., died at his home in Chicago on May 10 after an illness of two weeks. Heart disease brought on by old age was the immediate cause of his death. He was 71 years old and had been in active charge of his financial affairs up to the time of his illness. He was born in Michigan City, Ind., Apr. 6, 1845, received his primary education there and completed his education in private schools in Chicago, having removed to that city with his parents when about 19 years old. Starting his career on the Board of Trade, Mr. Blair later became connected with the packing firm of Culbertson, Blair & Co. Later he took up banking, and at the consolidation of the Merchants' National Bank, founded by his father, with the Corn Exchange Bank in 1903, he was elected vice-president. In 1899 he was made president of the Kennicott Co. He was a director of the consolidated elevated railway companies of the city and vice-president of the Chicago Home for the Friendless. He was a member of several of the better clubs of the city. On Oct. 26, 1882, he was married to Mary A. I. Mitchell, who, with four children, survives him.

MISCELLANEOUS NEWS

To Build Transmission Line—Burlington Railway and Light Co., Burlington, Iowa, will construct a 45-mi. transmission line to connect with the power plant at Des Moines, Iowa.

A Steam Turbine Recently Let Go at the plant of the Sheffield Brick and Tile Co., at Sheffield, Iowa. The cause of the failure is now under investigation and will be made public later.

Municipal Waterworks at Elk River—Plans are being prepared for the installation of a municipal water-works plant at Elk River, Minn., and for a water filtration plant at Thief River Falls, Minn.

North Dakota Electrical Improvements—Forest City contemplates installing an electric-light system at an estimated cost of $10,000. The Northern States Power Co. plans to extend an electric transmission line from Burlington to Foxholm.

To Install a Block Plant—A franchise authorizing the Speed Realty Co., which is putting up a series of buildings in Louisville, Ky., to cross streets and alleys to supply its own buildings with electricity, steam, etc., has been granted to the company by the city council.

Smoke Abatement in Louisville, Ky.—Under the direction of the Louisville Smoke Abatement League, a campaign looking toward the enactment of a more effective anti-smoke ordinance in that city is projected. It will be begun on June 1 with a meeting which will be addressed by Osborne Monnett, of Chicago, among others.

Electric Plant Enlargement in Virginia—It is reported from Bristol, Tenn., that the Electric Transmission Co., with a large plant in Lee County, Va., supplying mining operations in Lee and Wise Counties, Va., has purchased equipment for quadrupling the plant and that transmission lines will be constructed to carry the current to Cincinnati, Chicago and elsewhere.

New Power Plant Construction—The Puckett Creek Coal Co., Middlesboro, Ky., will rebuild the $10,000 electric power plant burned some time ago. Included in the plans of the promoters of the electric railway to connect Shelbyville and Frankfort, Ky., are two power houses. The Shelbyville & Frankfort Realty Co., E. H. Taylor, Jr., of Frankfort, president, is directing the project.

Rate Question in Seymour, Ind.—City officials of Seymour, Ind., have been advised that engineers of the Indiana Public Service Commission will shortly arrive in Seymour to make an appraisal of the plant there of the Interstate Public Service Co., on which to base the finding in the city's appeal for a reduction in rates. Six months ago the company rejected a schedule of reductions offered by the city, which then appealed to the state commission. The city contends that the plant of the company is not worth more than $200,000, although it is stated that dividends are being paid on the basis of a valuation of $450,000.

University Operates Public Water Plant—Probably the only university in the world which operates a public water plant for profit is the University of California, at Berkeley. This water utility, known as the Bear Gulch Water Co., serves a territory between Palo Alto and Redwood City, and was presented to the college as an endowment of the department of economics. The plant has a valuation of about $550,000, but up to the present time has been a liability rather than an asset, the operating revenue being just about sufficient to cover the interest on an outstanding bond issue against the property. This condition, however, is being alleviated through the coöperation of the state comptroller's office, which recently took over the management to place the enterprise upon a paying basis.

Connecticut Co. Building New Station—The Connecticut Co., New Haven, Conn., has awarded a contract to the J. G. White Engineering Corporation, New York, for the engineering and construction of a new steam-power plant at New Haven. The plans for this station are being prepared for an ultimate capacity of 100,000 kw. Construction work on the foundation has been begun. This plant will take the place of the company's old direct-current station at New Haven, and probably two substations will be built in New Haven for local distribution of current to the Connecticut Co.'s lines. The current generated by this new plant will be in addition to the electrical energy delivered to the Connecticut Co.'s lines by its other important stations, among which are those located at Waterbury, Bridgeport, Hartford and Berlin, Conn.

Explosion in Compressed-Air Line—An explosion of a 6-in. pipe re-feeder carrying compressed air to a line of air hammers in the American Hoist and Derrick Works, 63 South Robert St., St. Paul, Minn., occurred about 3 p.m., Apr. 24. The explosion burst the pipe and chamber surrounding it, raised the roof of a blacksmith shop and endangered the lives of ten workmen. Damage, however, was confined to about $1,000, a property loss. Prof. George B. Frankforter, dean of the College of Chemistry, University of Minnesota, before whom the facts were laid, advanced the theory that volatile oil in the cylinder had carbonized and the combination of oil, smoke and air at high temperature resulted in the explosion. R. W. Hargadine, state fire marshal, accepts